MODERN PLASTICS

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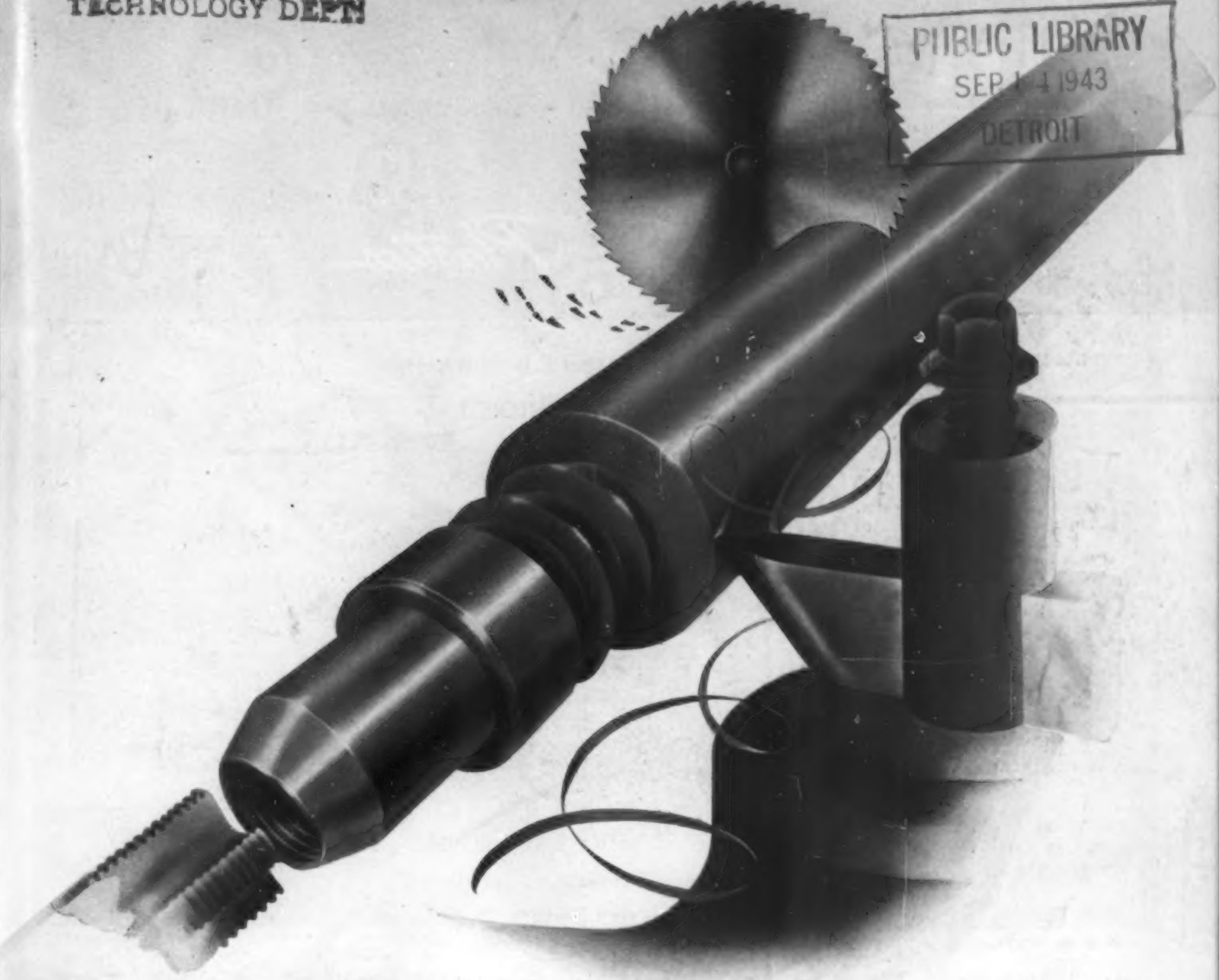
SEPTEMBER 1943



modern plastics

including Plastics ENGINEERING

VOLUME 21 SEPTEMBER 1943 NUMBER 1

● All editorial contents having bearing on military subjects have been released for publication in MODERN PLASTICS by the Armed Services.

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GENERAL INTEREST

PLASTICS ENGINEERING

TECHNICAL SECTION

NEWS AND FEATURES

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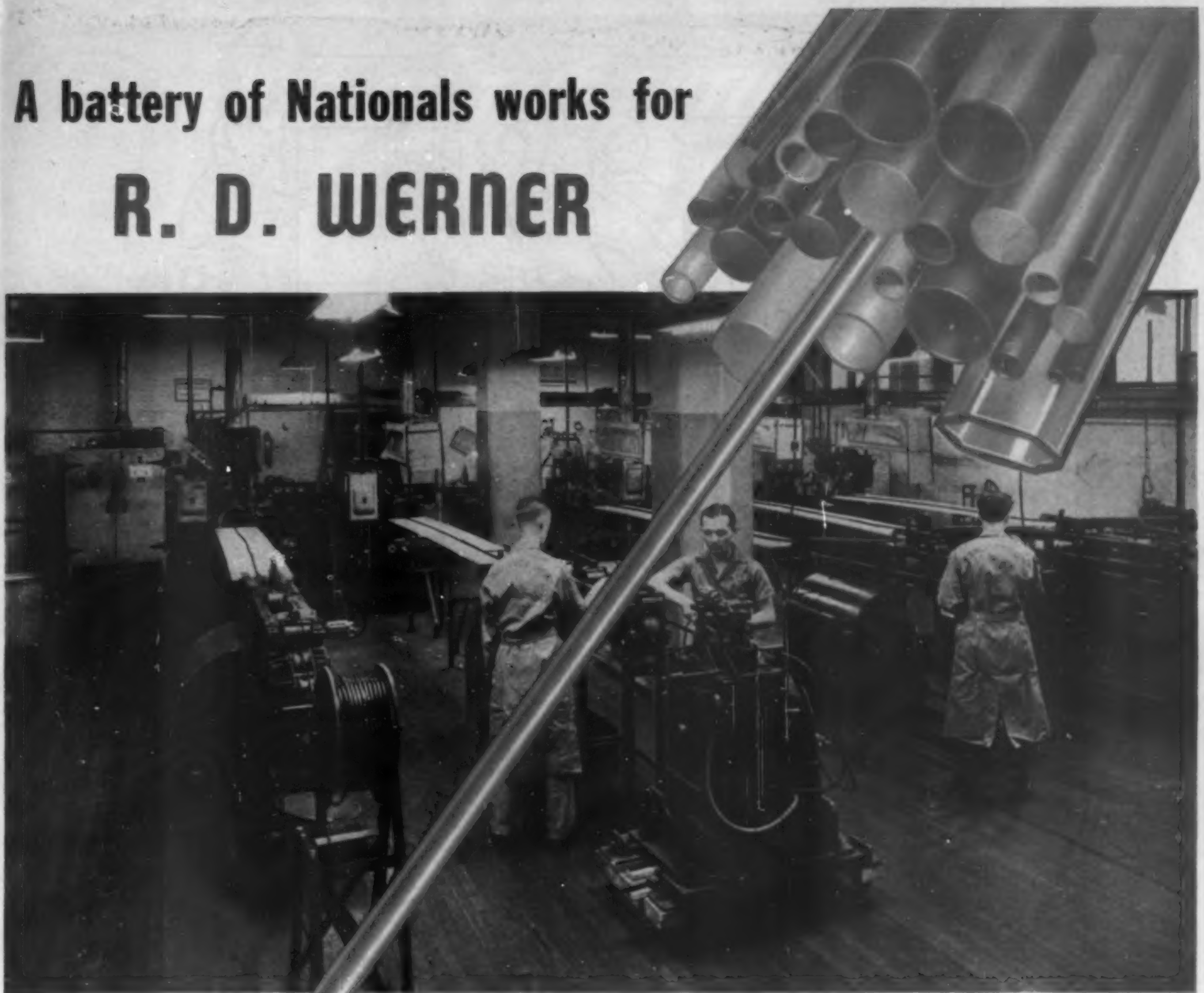
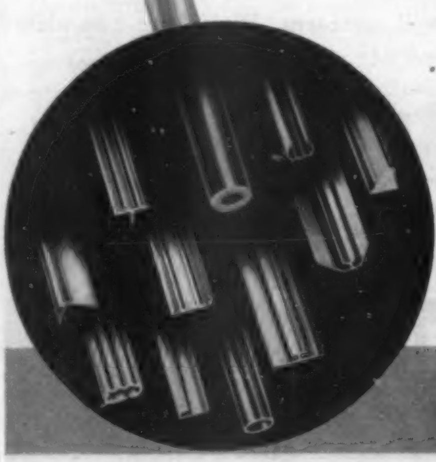




GLIMPSE OF THE FUTURE-TODAY

...as Du Pont "Lucite" serves America's Greatest Battle Planes

On Victory mission, the Consolidated PB4Y-1, Navy Patrol Bomber, mounts a pilot's enclosure and fore and aft turrets of Du Pont "Lucite." Easily adapted to big ships like this, "Lucite" can be formed into wide surface areas of great strength, permitting over 90% light transmission.

NO wonder that Du Pont "Lucite" methyl methacrylate resin—*America's outstanding acrylic plastic*—serves all of America's war planes mentioned on this page, and many, many others!

Crystal-clear transparent "Lucite" is strong, lightweight, capable of withstanding the impact of high winds. It's stable under sunlight, temperature and humidity extremes. Easily formed into broad surfaces, "Lucite" allows pilots, navigators, bombardiers and gunners maximum vision under every condition of war in the sky.

Enclosures of "Lucite" have high *shatter-resistance*. When properly designed, they won't fail under stresses such as those applied by gun-mounts—perform efficiently at high altitudes, even under substratosphere conditions. If damaged by gunfire, they can be easily repaired.

There's a glimpse of the future in the performance, the versatility, the long-lasting service of "Lucite." For, materials like this will be chosen by those engineers and designers in every field who will build our world of tomorrow.

BACK THE ATTACK—WITH WAR BONDS

This tail cone is one of 36 crystal-clear transparent parts of "Lucite" serving North American Aviation's famous B-25 Mitchell Bomber. Another example of how "Lucite" can be formed into intricate shapes to meet vital design requirements.

"Lucite" appears in the windshield and canopies of the Stinson L-5 *Flying Jeep*, used recently for reconnaissance work in Sicily. Here, "Lucite" gives pilots maximum vision while minimizing overall weight.

This nose-piece of "Lucite" gives peak performance in the Douglas *Havoc* A-20 attack bomber. The *Havoc* also carries a pilot's enclosure and gunner's turret of "Lucite." *America's outstanding acrylic plastic* serves aircraft also in many other ways—in parts unseen but vital.

Get this *free* booklet: The 114-page Manual on "Lucite," for aircraft designers, engineers, production men, and for fabricators of plastics, gives detailed information on fabricating, forming, repairing and general properties of "Lucite." For your *free* copy, write on your business letterhead to: E. I. du Pont de Nemours & Co. (Inc.), Plastics Department, Arlington, N. J., or 5801 So. Broadway, Los Angeles 3, California.

DU PONT

"LUCITE"

methyl methacrylate resin

BETTER THINGS FOR BETTER LIVING...*THROUGH CHEMISTRY*


The custom molder
can shape your business
Dotting the eyes of vital war workers over the country, light-weight, tough industrial goggles, made of Lumarith plastics, cut down wear fatigue. And, because of their low heat-conductivity, wearing comfort is unaffected by high or low working temperatures. . . . Here is another product (injection molded in 4 parts) to add to the growing list of improved designs that the custom molder, using high-impact-strength Lumarith plastics, is turning out for both military and civilian use. . . . If you are thinking in terms of molded thermoplastics but are unfamiliar with the way to go about making the changeover, we can help you. . . . **1.** Tell us what properties you require in your finished part: impact strength, light transmission, dielectric strength, dimensional stability . . . we will recommend the plastic for best results. . . . **2.** We put you in touch with the available custom molders best equipped to mold the piece by injection, transfer, or extrusion. . . . **3.** The custom molder will give you a quotation. . . . **4.** We work with the custom molder in selecting the formulation suitable for all factors of production technique in relation to dies, heat, pressure, flow, etc. . . . Success with plastics depends upon the right plastic and the right man at the machine. . . . Celanese Celluloid Corporation, *the first name in plastics*, a division of Celanese Corporation of America, 180 Madison Avenue, New York City. *Representatives:* Cleveland, Dayton, Philadelphia, Chicago, St. Louis, Detroit, Los Angeles, Washington, D. C., Leominster, Montreal, Toronto, Ottawa.
LUMARITH*
A Celanese* Plastic
*Trade Marks Reg. U. S. Pat. Off.

The Munising Paper Company

GENERAL SALES OFFICES • 135 SOUTH LA SALLE STREET • CHICAGO, ILLINOIS

To the Plastics Industry

Gentlemen:

Various branches of the plastics industry have counseled with us concerning their impregnating paper requirements. Some have found our technical and manufacturing facilities most helpful.

We, ourselves, do not impregnate, believing our field is that of a basic supplier to your industry rather than a processor.

The Munising Paper Company has, however, developed a precision method of manufacturing bleached pulps and specialty papers that seems to be of interest in the laminating field. For example -

Pulp Manufacturing:	Purification in the digesters is controlled to (plus or minus) 3.0% as measured by permanganate number. This assures a uniformity of pH controlled to the buyers specifications.
Bleaching:	Variation in reflectivity is limited to (plus or minus) 0.4 millimicrons as recorded by the spectrophotometer. On translucent laminations variations in shade are correspondingly reduced.
Paper Manufacturing:	Tolerances for weight, caliper, and absorbency (plus or minus) 2.5% both across the web and throughout the runs. Even absorption and level piling of sheets or winding of tubes result.

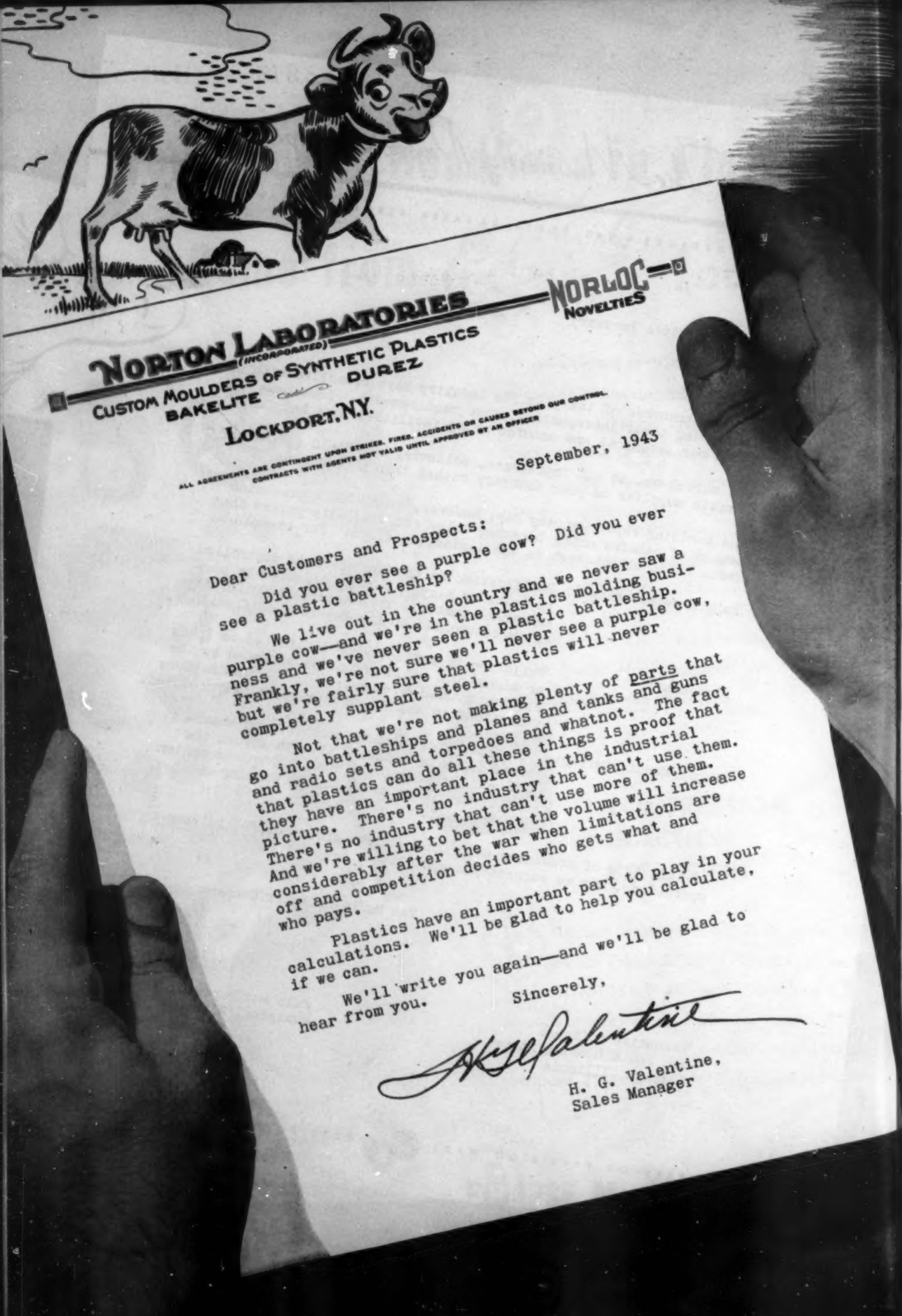
If this type of precision manufacture might prove helpful in your operations, may we suggest you contact us.

The Munising Paper Company

Pulp and Paper Mills:
Munising, Michigan

Executive offices:
135 South LaSalle Street
Chicago, Illinois

MANUFACTURERS OF PRECISION MADE PAPERS FOR MORE THAN FORTY YEARS



NORTON LABORATORIES (INCORPORATED)

CUSTOM MOULDERS OF SYNTHETIC PLASTICS

BAKELITE — DUREZ

LOCKPORT, N.Y.

NORLOC NOVELTIES

ALL AGREEMENTS ARE CONTINGENT UPON STRIKES, FIRES, ACCIDENTS OR CAUSES BEYOND OUR CONTROL. CONTRACTS WITH AGENTS NOT VALID UNTIL APPROVED BY AN OFFICER

September, 1943

Dear Customers and Prospects:

Did you ever see a purple cow? Did you ever see a plastic battleship?

We live out in the country and we never saw a purple cow—and we're in the plastics molding business and we've never seen a plastic battleship. Frankly, we're not sure we'll never see a purple cow, but we're fairly sure that plastics will never completely supplant steel.

Not that we're not making plenty of parts that go into battleships and planes and tanks and guns and radio sets and torpedoes and whatnot. The fact that plastics can do all these things is proof that they have an important place in the industrial picture. There's no industry that can't use them. There's no industry that can't use more of them. And we're willing to bet that the volume will increase considerably after the war when limitations are off and competition decides who gets what and who pays.

Plastics have an important part to play in your calculations. We'll be glad to help you calculate, if we can.

We'll write you again—and we'll be glad to hear from you.

Sincerely,

H. G. Valentine,
Sales Manager

THE NEW* SHELL GAME

*Customers Win Every Time!

You can't lose . . . Our game's on the sure side! Those with an insight on chrome plating make no mistake when they choose our *hard shell* . . . They know it will have what it takes!

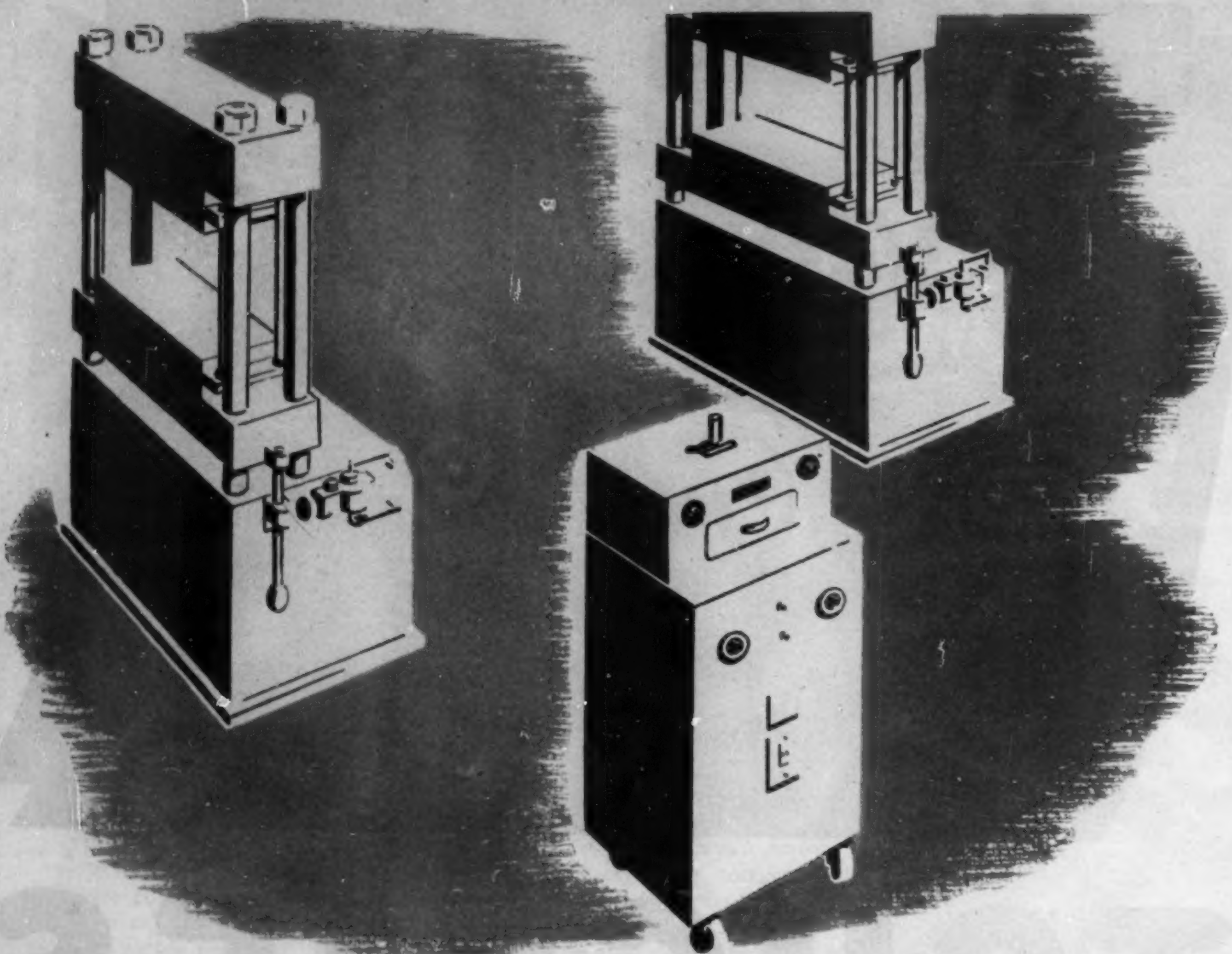
Industrial Hard Chromium plating, carefully maintaining the precision of the tool maker's art, gives to molds a surface that is twice as hard as ordinary steel—one that is highly resistant to wear, abrasion and corrosion. Its extremely smooth, slippery finish is a speed-up factor in forming and molding operations . . . a quality that also translates itself into a smoother and better finished product. Once plated and after long service, molds, moving parts, gauges and other equipment may be stripped of their shells and re-plated repeatedly—thus continually renewing useful life.

So, step right up, gentlemen . . . Try the *New* shell game! . . . We welcome every opportunity to prove that there isn't any surer Shell than one of Industrial Hard Chromium.

INDUSTRIAL HARD CHROMIUM Co.

"Armorplate for Industry"

15 ROME STREET • NEWARK 5, NEW JERSEY



Get more production from your press equipment with THERMEX

Thermex High Frequency Heating reduces over-all time cycles 50% or more, thereby doubling output of a press. Also, one or or more presses may be operated (one at a time) from a single Thermex. While one press is being closed, the material cured and press opened—preforms for the second press are being heated. With operations properly synchronized, time lags can be reduced to a minimum, thus providing continuous stepped-up production.

Thermex uniform heating of preforms makes a stronger and better product by increasing flow properties of the material in the mold and eliminating internal strains.

THERMEX
HIGH FREQUENCY EQUIPMENT
FOR HEATING NON-CONDUCTING MATERIALS
A GIRDLER PRODUCT

Write today for complete facts.

The GIRDLER CORPORATION
Thermex Division **Louisville, Kentucky**

★ *Buy another*
WAR BOND this week!


STEEL..STEEL..STEEL!
for the hungry jaws of industry
A CONTINENTAL-DIAMOND PRODUCT—
speeds wartime steel production
Steel rolling mills are making longer runs, holding closer tolerances, producing more vitally needed STEEL because of Plastic NON-metallic roll neck bearings. A C-D product, first applied experimentally in 1933, these NON-metallic bearings are now giving unprecedented service in steel mills everywhere, making an immeasurable contribution to the war effort by helping produce more and better steel.
The same research and engineering staff that developed and perfected C-D Plastic bearings is ready to help you with your "What Material?" problems. Men familiar with five basic NON-metallic products, laminated phenolic plastics . . . molded phenolic plastics . . . vulcanized fibre . . . Mica . . . Vulcoid, can help you determine where they can be used in your plant or product . . . to further the War effort . . . to prepare to meet the Peace. Send for booklet GF-3 which gives specific data on all C-D products.
LAMINATED
Plastic
NON-METALLIC
BEARINGS
Continental-Diamond FIBRE COMPANY
Established 1895 . . Manufacturers of Laminated Plastics since 1911 — NEWARK • DELAWARE

One Operation With LEA COMPOUND Eliminates Hand Filing

*Reports American Insulator Corporation**

Molding an idler crank in rag-filled Bakelite left a heavy flash at the parting lines—and dumped a stiff production problem right in the lap of American Insulator Corporation, New Freedom, Penna.

Formerly, each part was hand-filed to remove flash and the resulting seam was buffed. It was a slow process, so they searched for and found a better and a faster way.

> *"The laborious process was eliminated by the use of a single LEA COMPOUND operation. LEA COMPOUND is used on a soft cloth buff 7" in diameter, running at a speed of 2350 R.P.M. This change to LEA COMPOUND has permitted a definite SAVING in COST and TIME, and PRODUCES A BETTER FINISHED APPEARANCE than was possible by the hand-filing method."*

To meet other war production needs, LEA engineers have developed many new techniques. For example, by the use of various types of cone-shaped bobs, operating on a tapered spindle, counter-sunk holes of varying diameters can be burred effectively without filling threads or holes with foreign material.

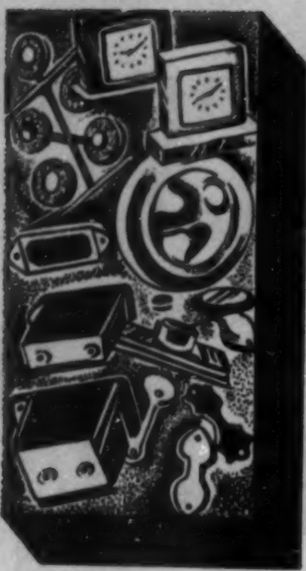
Write LEA in detail about your burring, polishing, or buffing problem. Invite a LEA engineer to call for a consultation. He will gladly help you solve your problem.

*Photographs and data courtesy American Insulator Corporation

THE LEA MFG. COMPANY

Waterbury 86, Connecticut

Burring, Buffing and Polishing . . . Specialists in the Development of Production Methods and Compositions.



mpossibles produced daily

The best way of learning has always been, in our estimation, by doing.

We learned a lot about plastics by making them for a long and varied list of customers fcr more than 20 years.

Since the war, we've made so many "impossibles" in shape and size and number of inserts that we no longer consider anything impossible in plastics. Probably a lot of these things were possible even before the war, but we never had the customers who needed them.

So we've learned a lot more about plastics, molding under duress, as it were. This, combined with the new post-war economic set-up (more materials, cheaper materials, cheaper and faster molding methods) should place plastics in the forefront of raw materials you will consider in your operation.

Perhaps we can help you plan now for plastics in your products, after the war.

"A Ready Reference for Plastics" written for the layman, is now in a new edition. If you are a user or a potential user of molded plastics, write us on your letterhead for a copy of this plain non-technical explanation of their uses and characteristics. Free to business firms and government services.

ARMY E NAVY

BOONTON MOLDING COMPANY

MOLDERS OF PLASTICS · PHENOLICS · UREAS · THERMO PLASTICS

BOONTON · NEW JERSEY · Tel. Boonton 8-2020

NEW YORK OFFICE

Chanin Bldg., 122 East 42nd Street, New York 17, N. Y., MUrray Hill 6-8540

Here they come!

THAT BRILLIANT TAIL-PIECE he's tying to the tank is the new Signal Corps identity panel for the Army's motorized equipment. Vivid red, glaring white, vibrant yellow, they flash to our aircraft "This is a U. S. tank . . . a U. S. truck convoy." The bright coated fabric reflects 90% of light. It is clearly visible two miles.

INTERESTING TO EVERY plastic-minded manufacturer is the fact that Ethyl Cellulose was the plastic coating which could meet the Army's stringent tests. No cracking or peeling at 20°F. *below zero*—or at 140°F. *above zero* with 95% humidity. No sign of stickiness—no bleeding of color—even at 200°F. Because it has the widest temperature range of any thermoplastic, Ethyl Cellulose is being used for war to the fullest extent of production—for water-proofing and flame-proofing textiles . . . for aircraft parts, canteens, steering wheels . . . for wire insulation and flexible tubing . . . and many secret uses. It is the plastic of important present usefulness and enormous post-war promise.

IF YOU WOULD LIKE TO know more about this newest of thermoplastics, the properties of which are under constant development through Hercules research, we invite you to write for Ethyl Cellulose literature, addressing Department MP-93, Hercules Powder Company, Wilmington 99, Delaware.

Fabric, Columbus Coated Fabrics Corp.; Coating, Hercules Ethyl Cellulose.

HERCULES

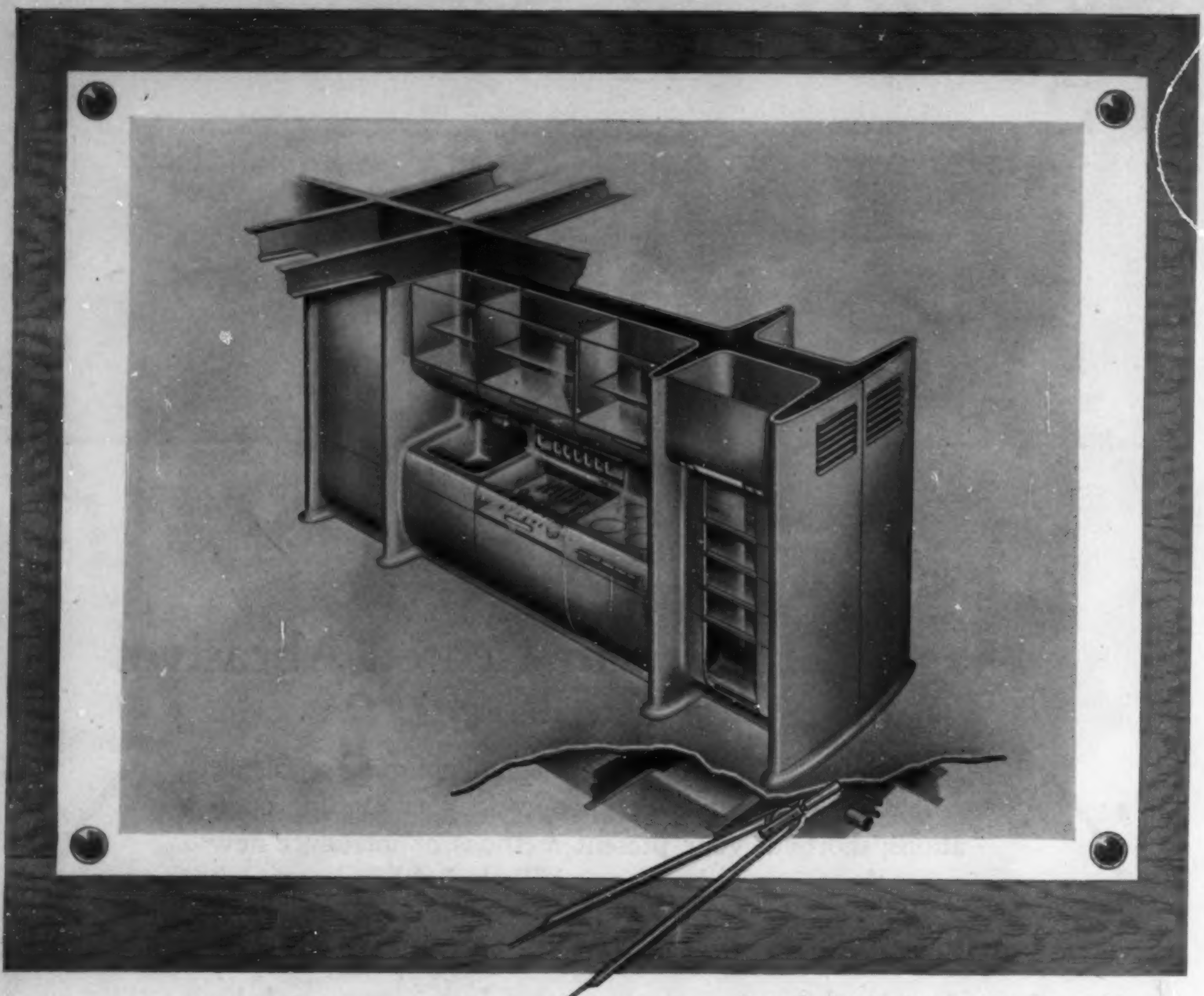
ETHYL CELLULOSE

★

TOUGH · FLEXIBLE · STABLE
LIGHTWEIGHT · ECONOMICAL · CLEAR

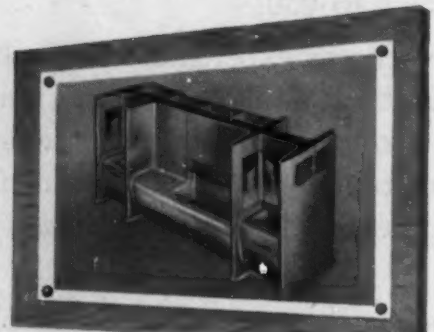
HERCULES POWDER COMPANY · WILMINGTON, DELAWARE
Incorporated

 800-76



From the drawing boards of Sundberg and Ferar

What's cooking— in home utility units



PLANS for postwar living would not be complete without some provision for added convenience, economy and beauty in kitchen and bath units . . . functional cores of the low priced homes of the future. Above are illustrations of what leading designers forsee with the aid of modern plastic discoveries.

The units have been layed-out back to back for simplicity in wiring and plumbing. And all fixtures, many of the connections and translucent materials would be plastic. Double, clear plastic fronts to refrigerator drawers also provide insulation . . . and plastic seat cover and fittings in the bath add to streamlined attractiveness.

Whether or not you are considering items like this for postwar production, you will be interested in the possibilities of plastics in modern design. These plastic applications are not limited to any one group of products either for industry or the consumer. To take full advantage of new developments in plastics for your future products, consult Kurz-Kasch plastic engineers, toolmakers and moulders . . . specialists in plastic design and production for more than a generation.

KURZ-KASCH

For Over 25 Years Planners and Molders in Plastics

Kurz-Kasch, Inc., 1417 South Broadway, Dayton 1, Ohio
Branch Sales Offices: New York • Chicago • Detroit • Los Angeles • Dallas • St. Louis • Toronto, Canada. *Export Offices:* 89 Broad St., New York City

Here's help on your

tough plastic pressing problems

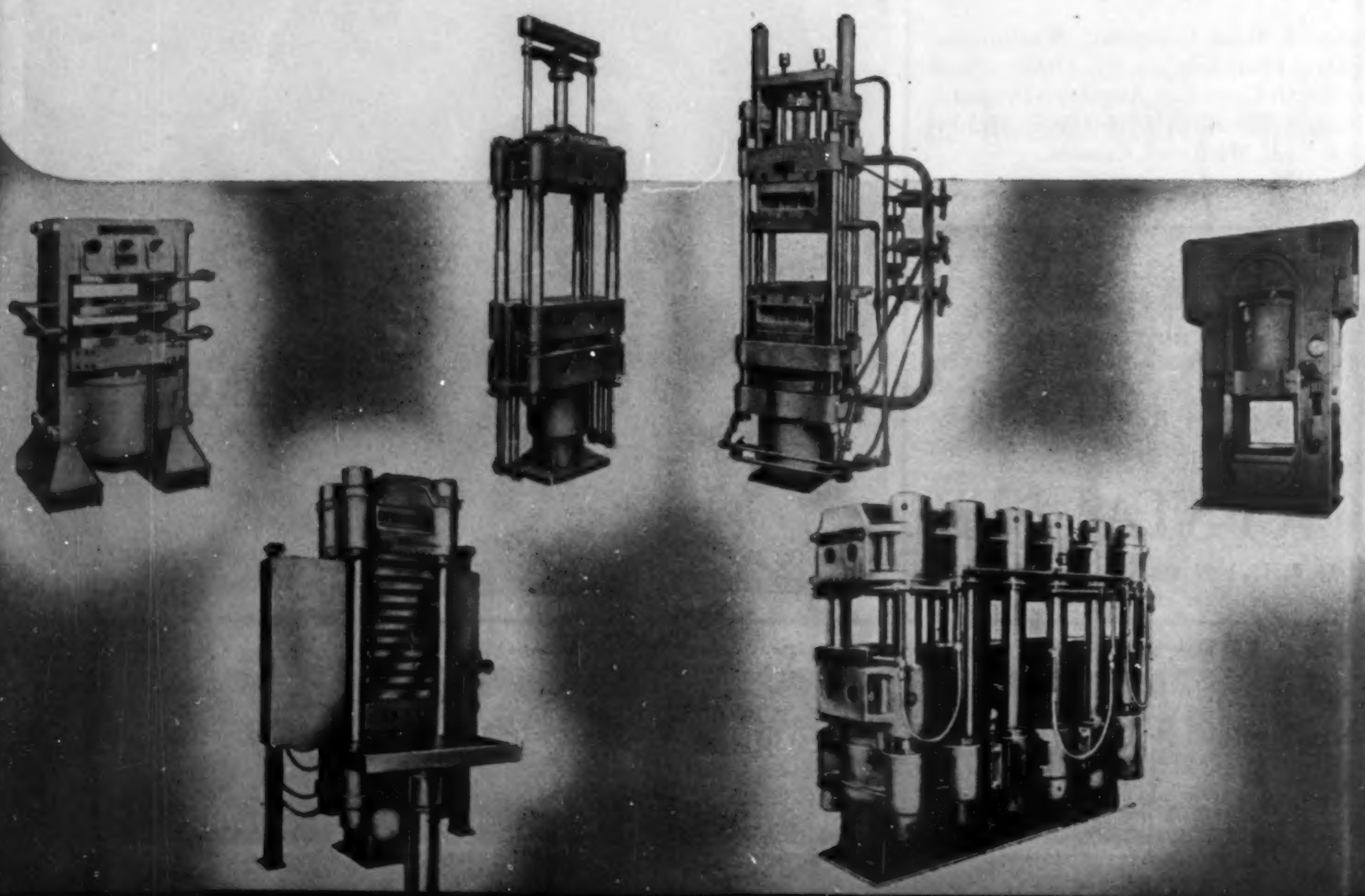
Among the Birdsboro general compression and transfer molding presses and multiple platen sheet presses shown here, you can find the answer to almost any plastic pressing problem you may have. Under the strain of 'round-the-clock war production, they are proving over and over again that they have the ability to pass the toughest tests to which any plastic press can be subjected.

If you have a press problem of either the present or future, we will be glad to help you solve it. Our engineers will welcome the opportunity of working with yours.

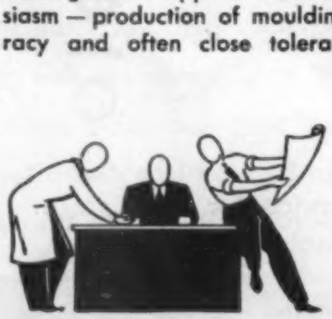
BIRDSBORO STEEL FOUNDRY & MACHINE COMPANY • BIRDSBORO, PA.

BIRDSBORO

HYDRAULIC PLASTIC PRESSES



The injection mouldings in our lobby showcase are more than mere samples. They represent vital problems solved for the purchaser — things like functions in design which our engineering and die making staffs approach and master with enthusiasm — production of mouldings with keen accuracy and often close tolerances — unbelievably rigid inspection — and fast delivery schedules constantly maintained. • These things are skills — skills ready to be called on for post-war plastics engineering — for suggestions on how to improve your production for better merchandising with the use of plastics. They form a plastics service of wide scope and down-to-earth knowledge with which we want you to be familiar.



For Custom Injection Moulding . . . try the Trio

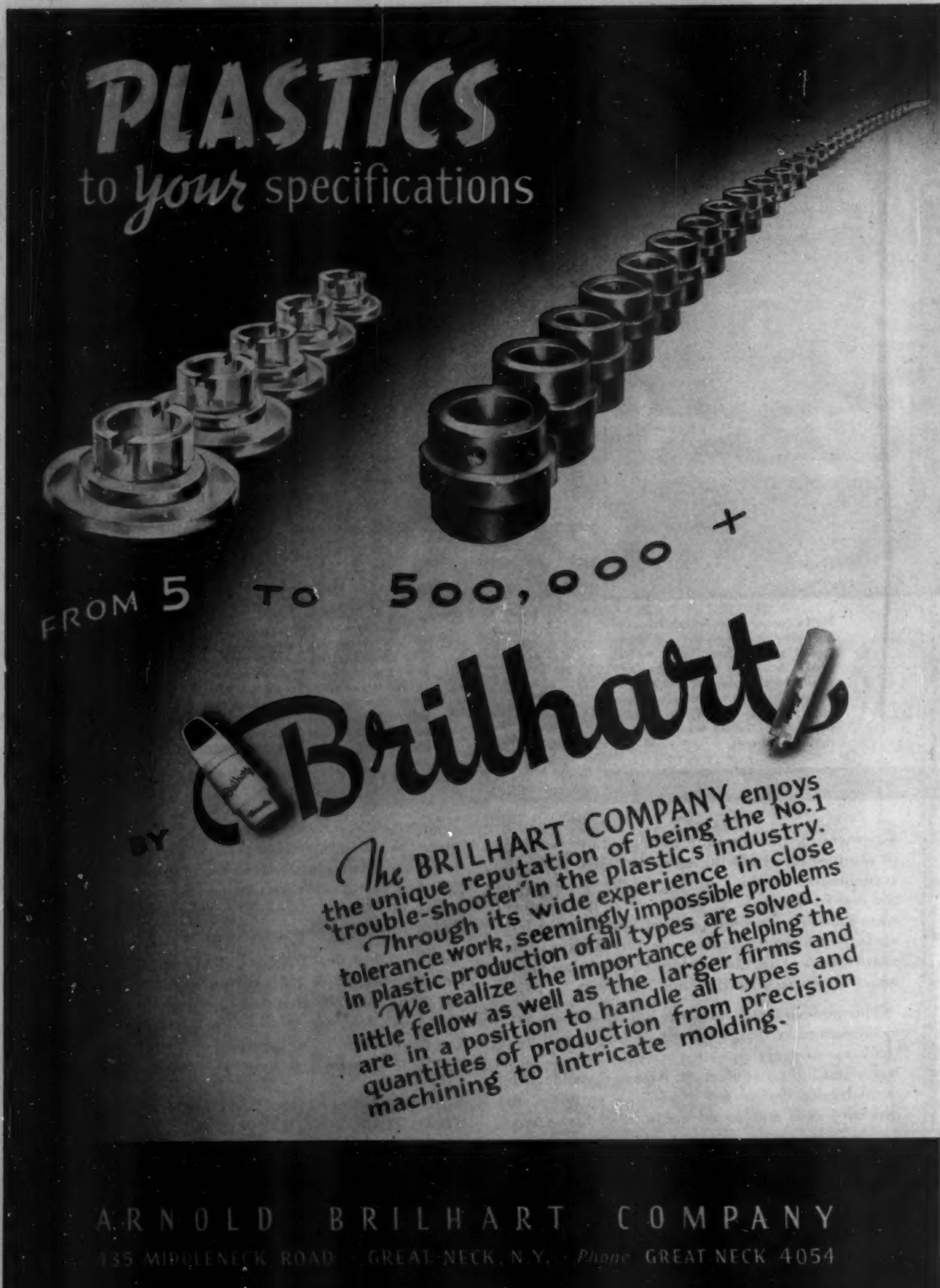
ARMY E NAVY

Custom Injection Moulders

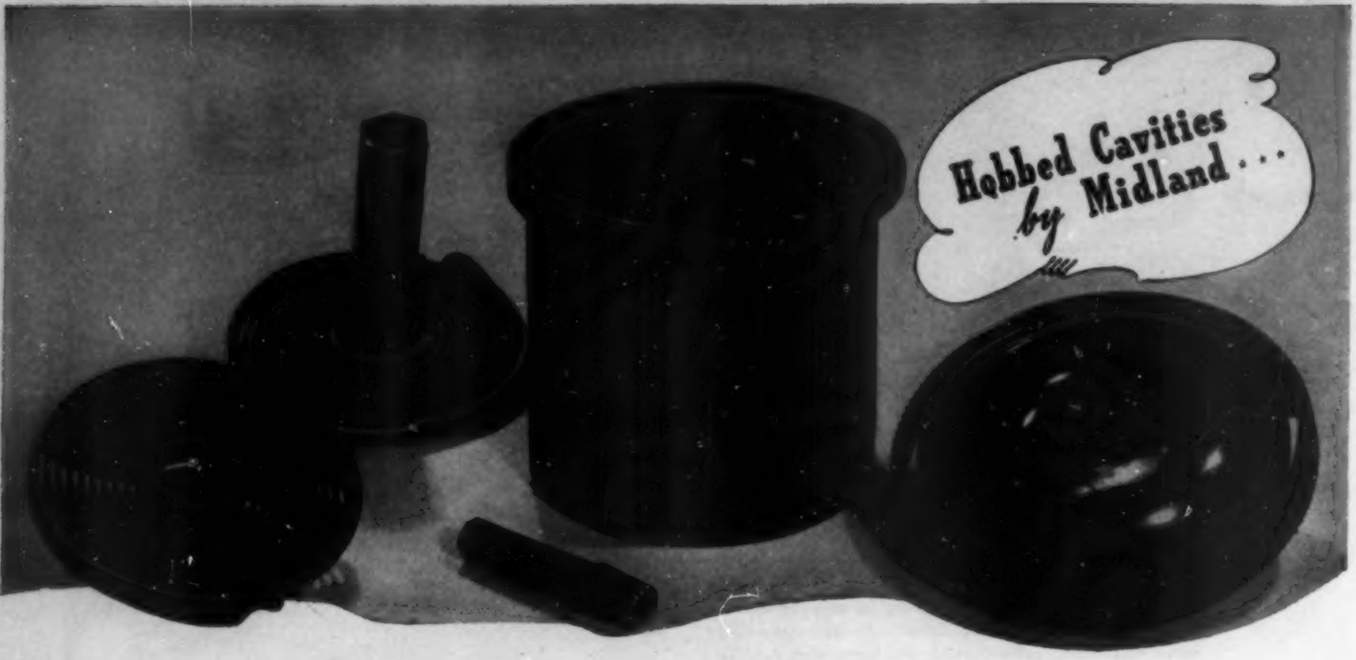
wmp

WORCESTER MOULDED PLASTICS COMPANY

8 GRAFTON ST., WORCESTER, MASS. • 17 E. 42nd ST., NEW YORK, N.Y.



PLASTICS
to your specifications
FROM 5 TO 500,000 +
BY Brilhart
The BRILHART COMPANY enjoys the unique reputation of being the No.1 "trouble-shooter" in the plastics industry.
Through its wide experience in close tolerance work, seemingly impossible problems in plastic production of all types are solved.
We realize the importance of helping the little fellow as well as the larger firms and are in a position to handle all types and quantities of production from precision machining to intricate molding.
ARNOLD BRILHART COMPANY
135 MIDDLENECK ROAD · GREAT NECK, N.Y. · Phone GREAT NECK 4054



This Mold Job Has Everything!

★ Yes, it's a film developing tank, made back before the war ... And though we've made, and are still making molds and dies for many intricate parts used in military equipment, this sample of pre-war work still represents an exceptional achievement, combining such a wide variety of operations in the making of its molds. The cover mold was hobbed, then engraved. Other parts, particularly the spool heads with spiral ribs, involved machine operations of the utmost precision. (Notice one spool head is inverted to show the annular slots more clearly.)

If your war-time production, or peace time planning requires plastic molded parts, of any degree of intricacy, let us put our knowledge and facilities at your service.

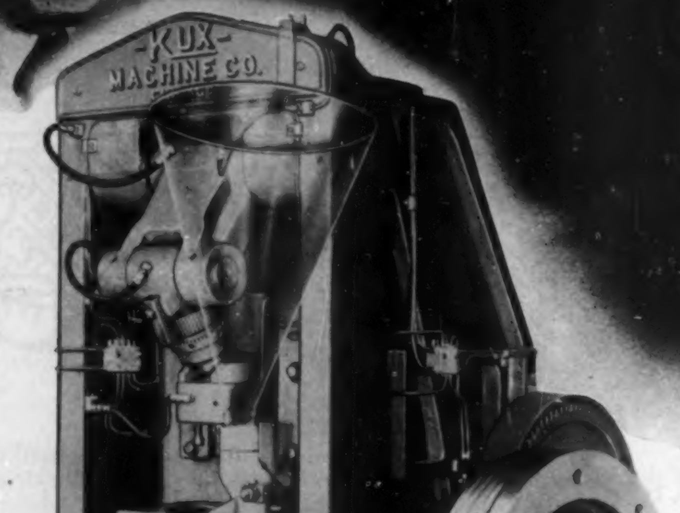
MD&E

MIDLAND DIE AND ENGRAVING COMPANY

1800 W. BERENICE AVENUE · · · CHICAGO, ILLINOIS

Makers of Plastic Molds · Die Cast Molds · Engraved Dies · Steel Stamps · Hobbings · Pantograph Engraving

PLENTY RUGGED

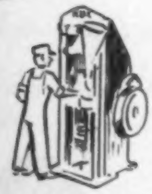


Kux Preform Presses

THE NEW MASSIVE MODEL 65 PRODUCES PREFORMS 3" DIAMETER, HAS A 3" DIE FILL AND APPLIES 75 TONS PRESSURE

This rugged preform press with its heavy duty, one-piece cast steel main frame will produce odd shapes as well as round preforms. The pressure applied by both top and bottom punches results in more solid, dense preforms, which have less tendency to crumble or break during handling. This new Model 65 press is built to safely withstand high pressures of up to 75 tons at top production efficiency.

Choice of a complete size range of machines in both single punch models and multiple punch rotaries is also available.



Model 65

● Write Dept. P for catalog or demonstration

KUX MACHINE COMPANY
3924-44 W. Harrison St., Chicago

SOUTH BEND LATHES

BUY WAR BONDS

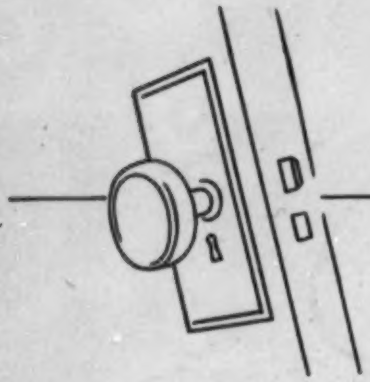
War production demands uniform accuracy. Loss of time or the waste of scarce strategic materials because of variations in machining cannot be tolerated. There is no place in our war production plan for equipment that cannot be relied upon to maintain required tolerances.

Sound design and careful workmanship give South Bend Lathes the dependable precision that assures uniform accuracy. Built by skilled craftsmen who take pride in their work, they are capable of maintaining split-thousandth tolerances on all work within their capacity. Their unvarying performance speeds production on the most exacting machine operations and assures perfect interchangeability of parts and units.

There is a South Bend Lathe for most war production requirements. The Engine Lathes are made in 9", 10", 13", 14½", and 16" swings, with bed lengths from 3' to 12'. The Toolroom Lathes are made in 10", 13", 14½", and 16" swings, with bed lengths from 3' to 8'. The Turret Lathes are made in 9" and 10" swings, with 3½' bed lengths. These lathes are described in Catalog 100C which will be sent upon request.

SOUTH BEND LATHE WORKS

SOUTH BEND, INDIANA • LATHE BUILDERS FOR 36 YEARS



"You think YOU'RE in a hole!"

"They call this a fox-hole. That's stretching a point. I don't think a fox would go for it. Not with shells tearing up the earth, sending slashing fragments flying through the air. Still, cover is cover, even when it comes by the inch. I'm not kicking.

"You folks at home aren't kicking, either—most of you. But now and then we get a grousing letter from someone who ought to thank his lucky stars for everything America gives him, wartime *or* peacetime.

"You've got homes, not smoking ruins . . . kids who play in safety . . . better food . . . and more of it than anywhere else. You're free to speak as you please . . . choose your own religion . . . and work in a job like yours.

"If anybody at home thinks he's in a hole about rationing . . . or anything else . . . ask him if he'd trade it for a fox-hole."

★ ★ ★ ★

Let's help this man in the fox-hole by the way we spend our time and our money. Let's give our blood more often. Let's take on extra duties in civilian defense. Let's buy bonds over and above our quota.

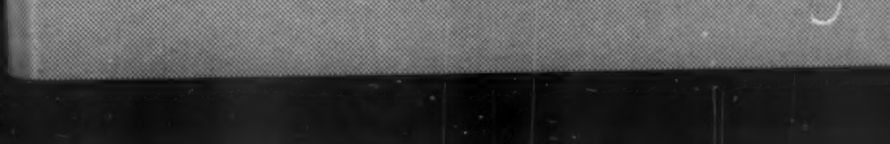
We of The Watson-Stillman Company are glad that our production serves America's war industries so directly. There are war jobs for all the products we make.

The Watson-Stillman Company, Roselle, N. J., Engineers and Manufacturers of Hydraulic Presses, Pumps, Wire Rope Shears, Jacks, Forged Steel Fittings and Valves.

WATSON-STILLMAN

Hydraulic Equipment, Valves, Forged Steel Fittings

Watson-Stillman Molding Presses, like this one, are turning out communications equipment for the Signal Corps and other branches of the Armed Services. Just another W-S Machine gone to War.



NOTICE

TO READERS OF MODERN PLASTICS

✓ Shown at left is one of a series of Watson-Stillman advertisements appearing in general business publications.

✓ It is reprinted here because of the type of molding press shown and the interest which members of the plastics industry may feel in the use to which this machine is put.

✓ Write for further information on Watson-Stillman presses for the fabrication of plastics. They include injection molding and fully automatic and semi-automatic compression molding machines.

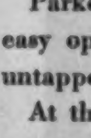
SEE HOW IT PAYS TO CHOOSE the *simplest* fastening method

Question every fastening! . . . . you save man-hours, lower costs, get better assemblies by using P-K Self-tapping Screws.

Parker-Kalon Self-tapping Screws require only one easy operation . . . simply drive them into plain, untapped holes. The result is a tight, secure fastening.

At the drafting board, or on the assembly line, be sure to find out if you can use the simple P-K method before you put up with a difficult, more costly one.

Ask for a P-K Assembly Engineer to check over fastening jobs with you. He'll help you search out all opportunities to apply P-K Self-tapping Screws. You'll find his advice unbiased. If you prefer, mail in assembly details for recommendations. Parker-Kalon Corporation, 190-200D Varick Street, New York 14, N. Y.



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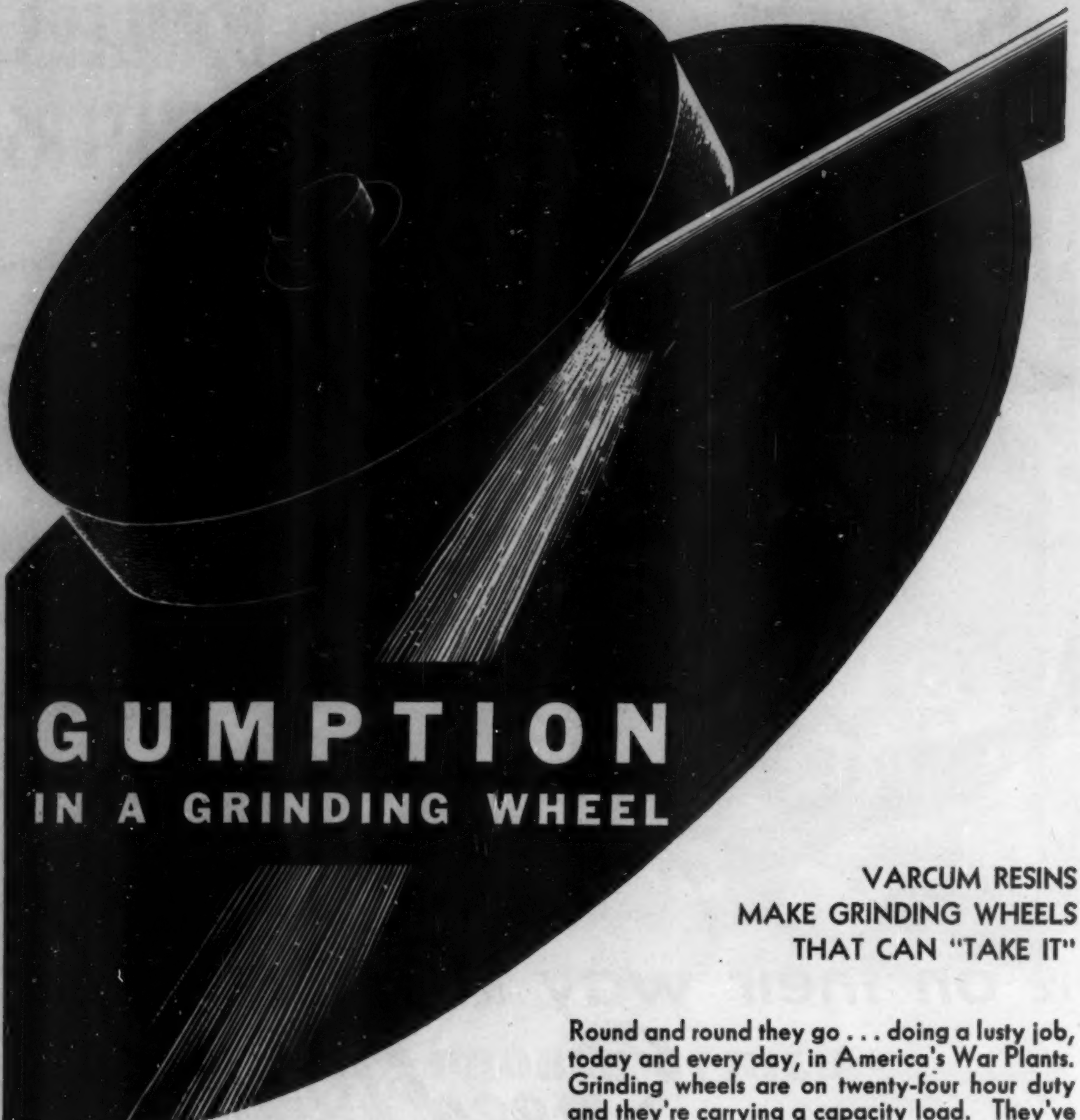
GUMPTION
IN A GRINDING WHEEL

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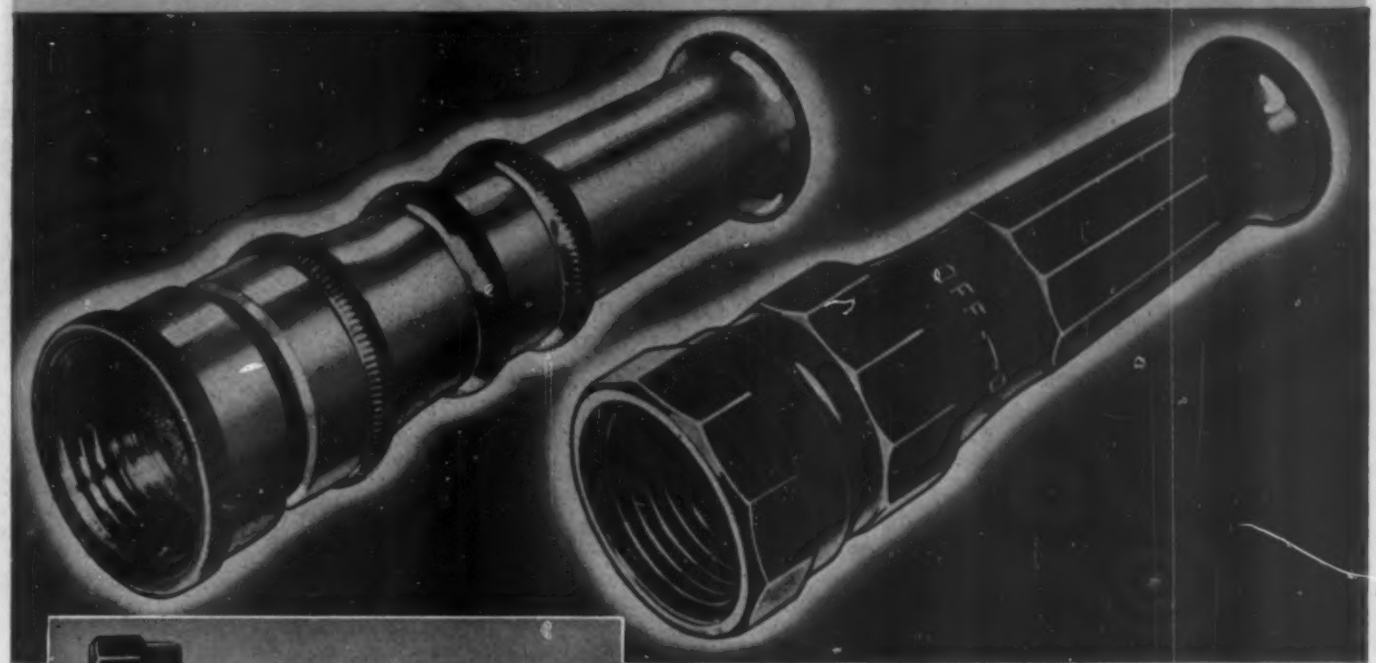

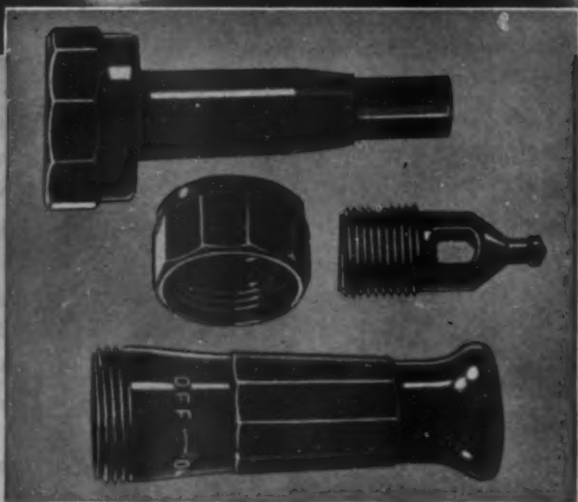

Plastic parts of hose nozzle designed and molded by Amos

Plastineering is a word we've coined to mean—engineering a part or product for conversion to *fast, efficient plastic molding* . . . Amos plastineering has helped many companies to keep their products on the market during the war. The hose nozzle job shown here is a typical example. And now Amos plastineering is working for many companies on developments for after the war—redesigning parts and products to make them more salable and profitable in molded plastics. Amos can help you with plastineering now—so you'll be ready for fast production to capitalize on the big demand when peace comes. The 56-page Amos picture-portfolio tells you what you want to know about our facilities and abilities. Write for it today.

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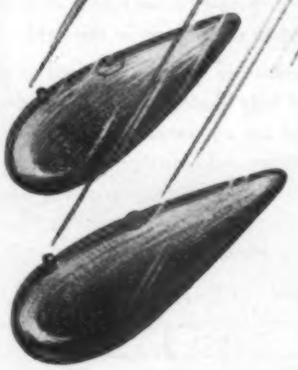

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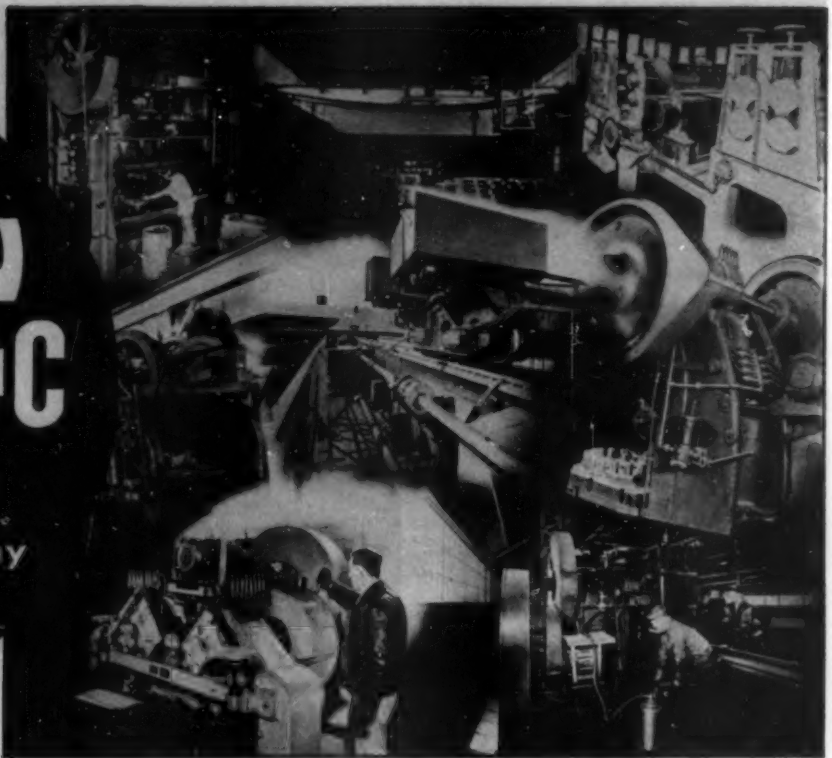

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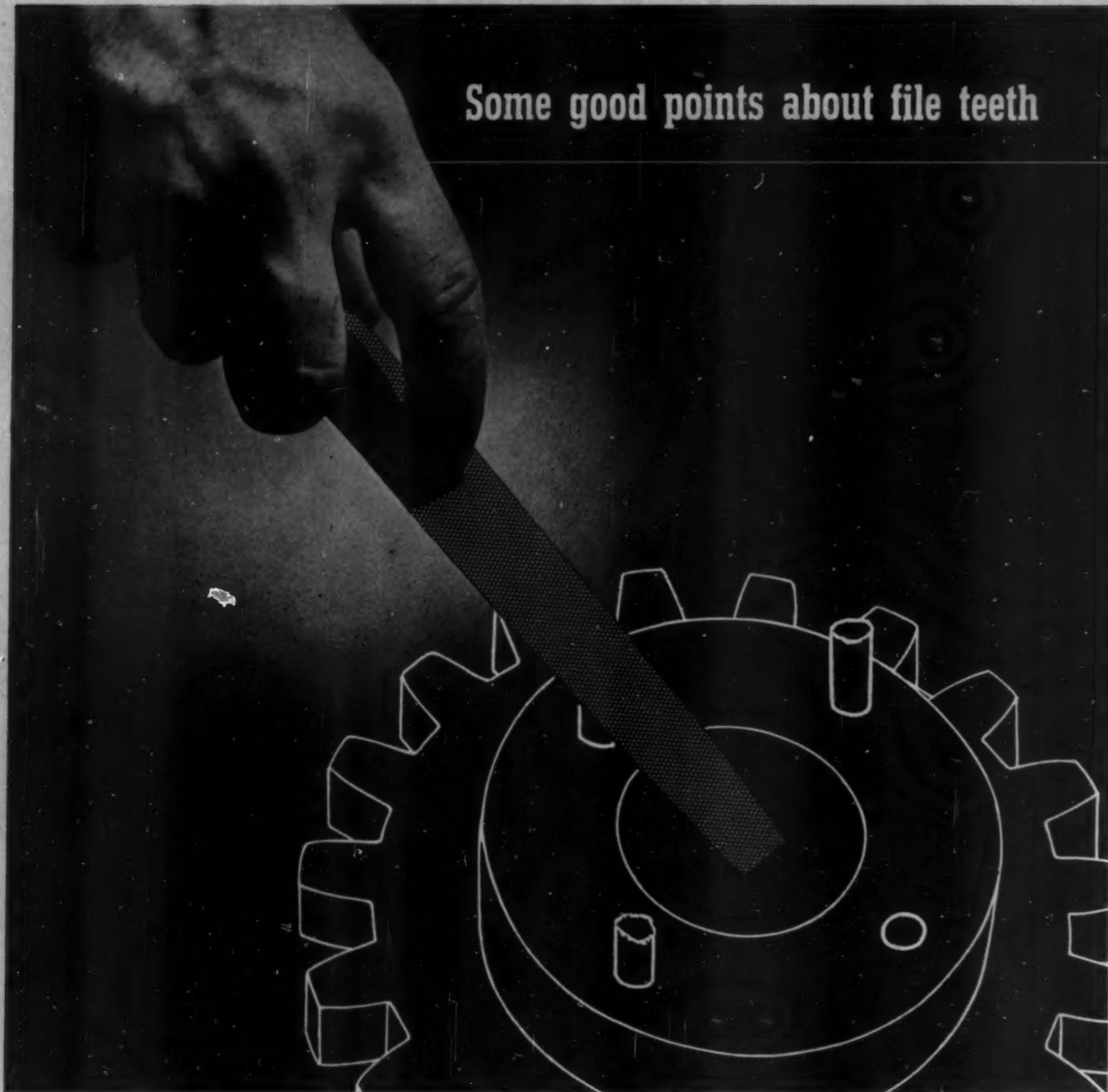

Roughing down sprues with a Nicholson double-cut (Flat) file

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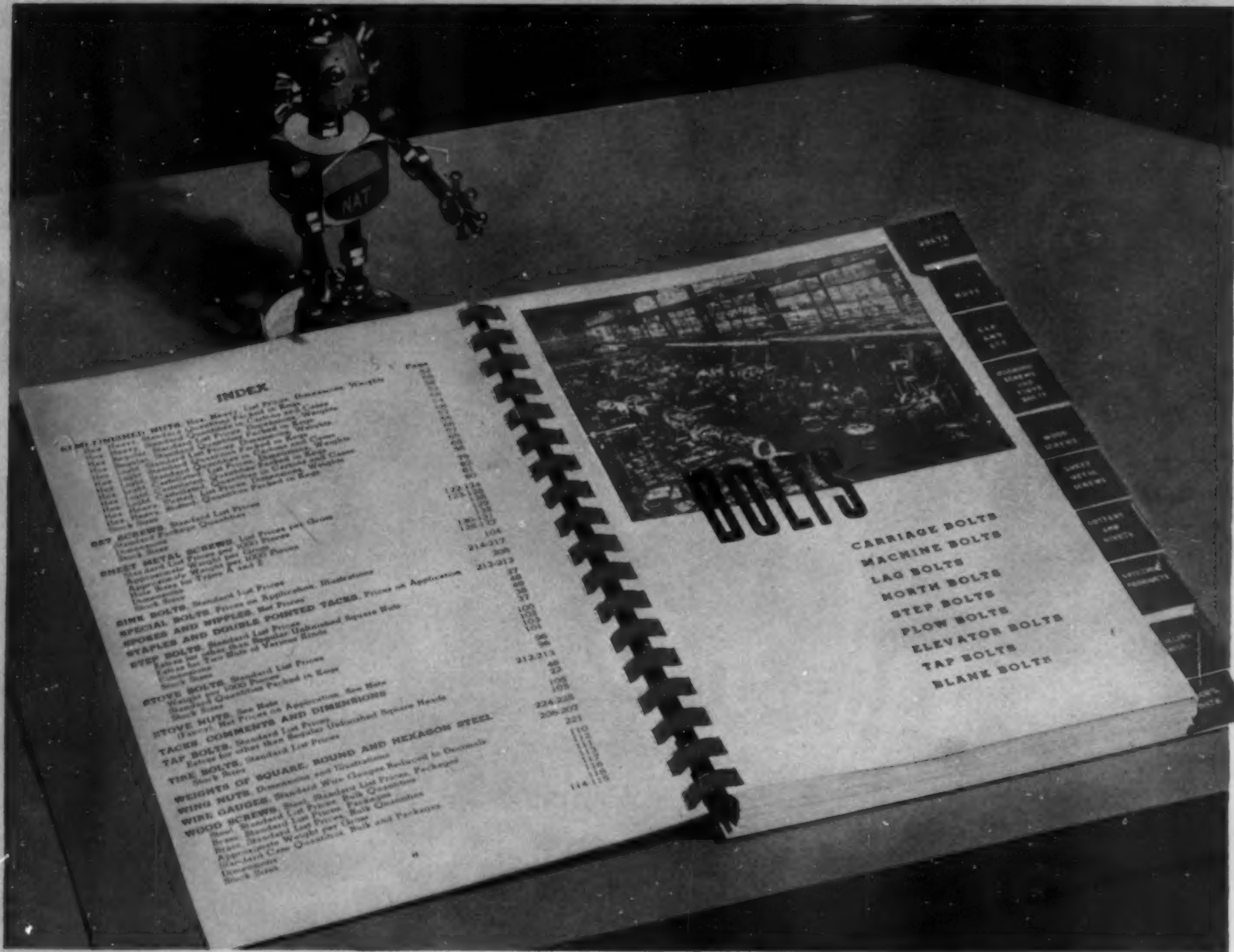

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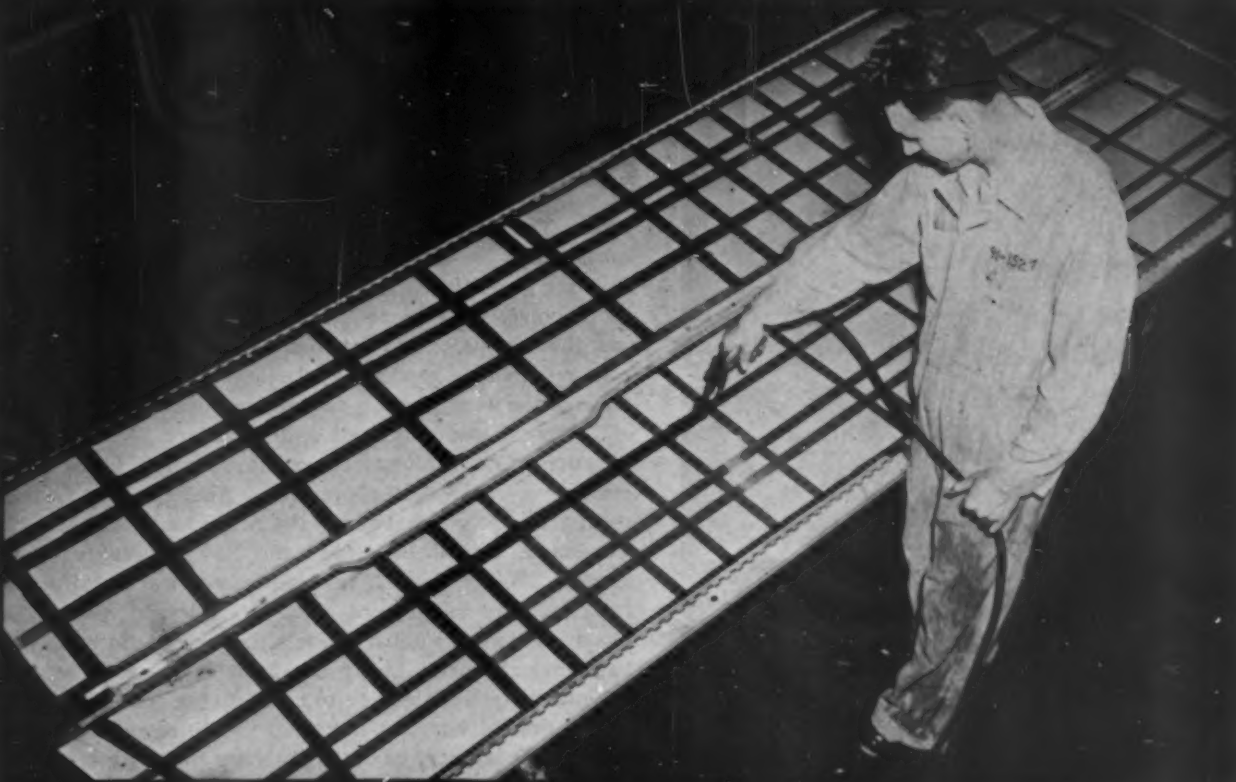
SEPTEMBER 1943 VOLUME 21 NUMBER 1



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1—*When Cycleweld replaces riveting in the assembly of a fighter plane's metal wing flap, 900 rivets are eliminated. Here Cycleweld cement is applied to skin and edge with a stripping gun*

Cycleweld—a new bonding process

PLASTICS' long-awaited entry into major structural applications in automobiles, airplanes and houses is an immediate postwar possibility as the result of a wartime development which until now has been closely guarded by the military. This is Cycleweld,* a new process for permanently bonding together and to each other metal, wood, plastics, ceramics, fiber board and rubber in any desired combination to form structures that are stronger, lighter and cheaper than those joined by conventional methods.

Cycleweld over the last year has been thoroughly tested and accepted for aircraft applications, in which it unites aluminum alloy, wooden and rubber parts without riveting or welding and at such strength that no Cyclewelded bond ever has been broken by vibration. In all tests, the metals or other materials joined have given way before the bond.

* The Chrysler Corp., which developed the process in its Production Research Department, is now in production on scores of Cyclewelded parts for fighter planes and bombers, and 30 other companies in war work are using Cycleweld under free license from Chrysler for the duration and 6 months thereafter.

In most of the aircraft parts where it is now used, Cyclewelding joins metal to metal. In one wing flap, for instance, the same aluminum parts—ribs, stringers and stiffeners—are used as in conventional riveted construction. But Cyclewelding eliminates 900 rivets in the wing flap alone, effects a tremendous time saving, cuts cost by 30 to 35 percent and produces a flap that is lighter and stronger than its riveted counterpart.

Despite the advantages already demonstrated, Cycleweld so far has been handicapped by the fact that it merely has been adapted to riveted or spot welded construction designs. Its originators feel that its full possibilities will not be realized until it is used in a structure expressly designed for it. There is a strong probability that the first such structures will be aircraft and ships using a large amount of plywood, where Cyclewelded wood-metal fittings offer tremendous new strength possibilities.

Designers vision a new Cycleweld-engineered fighter

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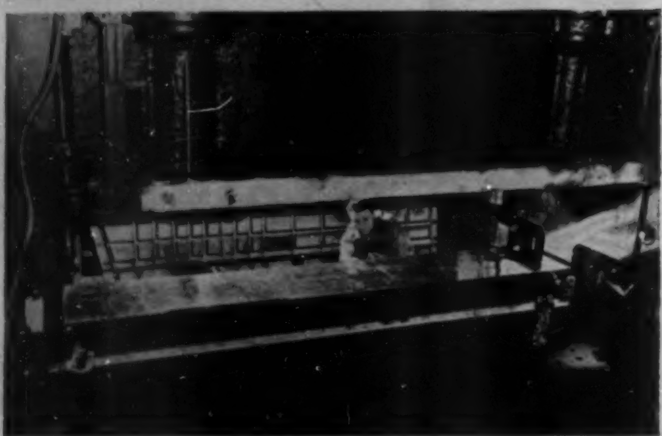

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plane, using unprecedented amounts of plywood, which would give superior maneuverability at about one-third the weight, one-fourth the cost and one-fourth the production time. This plane, able literally to fly rings around anything now in the sky, could have hundreds of Cyclewelded parts, and at each point where plywood joined metal there would be a wood-metal Cyclewasher to carry the load. Designers also foresee a cargo ship built largely of plywood which could have several hundred Cyclewelded parts.

Cycleweld cement itself is a thermosetting plastic, the exact composition of which cannot be revealed at this time. The operation of Cyclewelding is accomplished by putting the synthetic plastic Cycleweld cement on the surfaces to be connected and then applying heat and pressure to the joint. The process can be used on any aircraft or similar subassembly to which moderate pressure can be applied. Riveting or bolting is better only at points where there will be cleavage. The name "Cycleweld" is derived from the fact that the process is essentially the cycle of pressure and heat required to produce a plastic "weld." In the usual sense of the word, there is no welding involved.

Cycleweld was conceived and developed by S. Gordon Saunders, Chrysler research expert and now head of the company's Cycleweld Laboratories. Aiding in the development of the process have been the Army Air Forces Matériel Command, Wright Field, and the Navy Bureau of Aeronautics, Philadelphia. When it became clear that the aircraft industry might need a lot of Cycleweld cement, the Goodyear Tire & Rubber Co. was commissioned by Chrysler to manufacture it. Today Goodyear is supplying some of the raw materials which go to make up the cement.

The process was first described to 200 representatives of the aircraft industry at an Army-Navy three-day conference last October in the Horace H. Rackham Educational Memorial Building in Detroit. Striking demonstrations of the variety of materials that can be joined by Cycleweld cement were presented, and 875 individual specimens were prepared and tested to show the strengths obtained. At that time the publication of information on the process was forbidden. Much additional experimentation has since been carried on, and even greater possibilities have been demonstrated.

Aircraft stabilizers now being fabricated by the Cycleweld method withstand static loading and severe vibration tests just as well as—and in many instances better than—spot welded or riveted stabilizers. The process is particularly impressive in withstanding vibration, for—as stated above—there has never been a case in tests in which the bond itself failed under vibration.

Superior strength alone might not be sufficient to induce widespread adoption of the Cycleweld process, but even

2—Group of 80,000-lb. hydraulic presses used for Cyclewelding metal to metal. That in left foreground is spring loaded with bomber parts containing corrugated sections. 3—Wing flap frame loaded in press is about to have aluminum skin Cyclewelded in place. 4—Completion of wing flap requires slight supplementary riveting. Workmen in foreground are trimming excess metal and installing bearings. Girl operator is drilling rivet holes. 5—Metal wing flap fabricated by conventional riveting (above) and by Cyclewelding (below). Former contains 1200 rivets, latter but 300. Arrows show where rivets are eliminated in latter, which is lighter, more rigid. So far, no wing flap has failed under vibration tests

more important in postwar applications is the fact that the process is far quicker and less costly than riveting or spot welding. On one part alone, Chrysler has found that it can save 90 percent in costs as compared with riveting, and greatly reduce manufacturing time. The same is true, in greater or less degree, with all parts that can be Cyclewelded. On one stabilizer built with Cycleweld methods the number of rivets has been reduced from 5500 to about 30, and the resulting stabilizers are stronger and more rigid.

Ultimate development of the Cycleweld method to its fullest extent will make it possible to design and build airplanes in which rivets and spot or seam welds will be virtually eliminated. The factors of saving in manufacturing time and costs, as well as that of superior plane performance through reduction in weight, are obvious.

Cycleweld offers particularly outstanding advantages to wood-constructed aircraft. On one experimental airplane in which nuts and bolts on the most important beam fittings were practically eliminated by the use of Cycleweld, a weight saving of more than 1700 lb. was achieved. In wood aircraft construction, Cyclewelding is particularly important in bonding plywood to metal at each point where it is necessary to attach a metal fi.ting. For this purpose, the Cyclewashers—which are technically load distribution pads formed by Cyclewelding birch or walnut veneer to a thin piece of Alclad or steel—are widely used.

Two distinct types of Cycleweld cement are now being produced. One is used to bond any material except rubber; the other will bond any material to natural and most synthetic rubbers. Cyclewelding with either cement is simple. Only comparatively low curing temperatures and low pressures—sufficient to insure intimate contact of the faying surfaces—are required.

The first type of cement—here designated as Type A—is used to bond most metals, woods, thermosetting plastics, ceramics and fiber board together or to each other in any combination. There are many possible means of applying the necessary heat and pressure for the actual bonding, depending upon equipment available and to some extent upon the size and shape of the parts being jointed. Chrysler suggests the use of 1) pressure fixtures, such as hydraulic presses (Fig. 2), spring-loaded mechanical presses or spring-loaded clamps; 2) distribution pressure pads; and 3) dies made of any material which will withstand curing temperatures for an indefinite curing cycle.

Type B cement bonds other materials to rubber at considerably lower pressure than Type A, with 25 p.s.i. generally being recommended. Equipment for applying pressure may be hand fixtures or press equipment, hydraulic press with sensitive control, mechanical press with variable daylight

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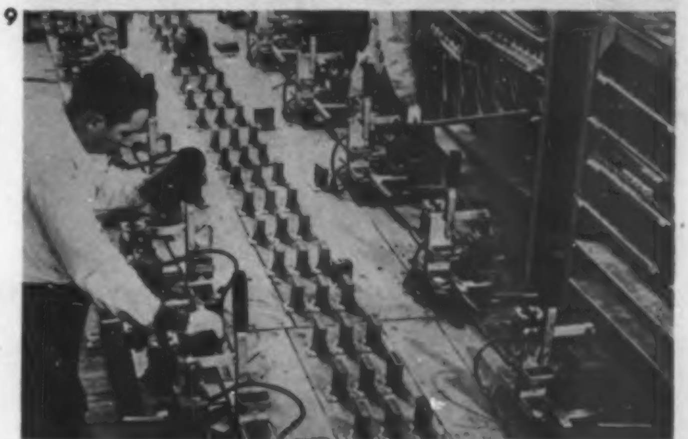

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6—Loading a hydraulic press with corrugated metal bomber floor sections. Flat sheet (on table at right) is Cyclewelded to corrugated piece to complete section. Here Cyclewelding replaces spot welding. 7—When metal is Cyclewelded to rubber, as in glider ski pedestals, first step is chemically cleaning the metal parts in alkaline solution, water and pickling bath. No hands touch them after start of operation. 8—Steel stampings and Buna S rubber blocks are brush coated with Cycleweld cement. 9—Batteries of toggle clamp fixtures with cartridge heaters in the clamping pads are used for curing the pedestals. 10—Here workmen are doing small amount of spot welding which the steel parts require

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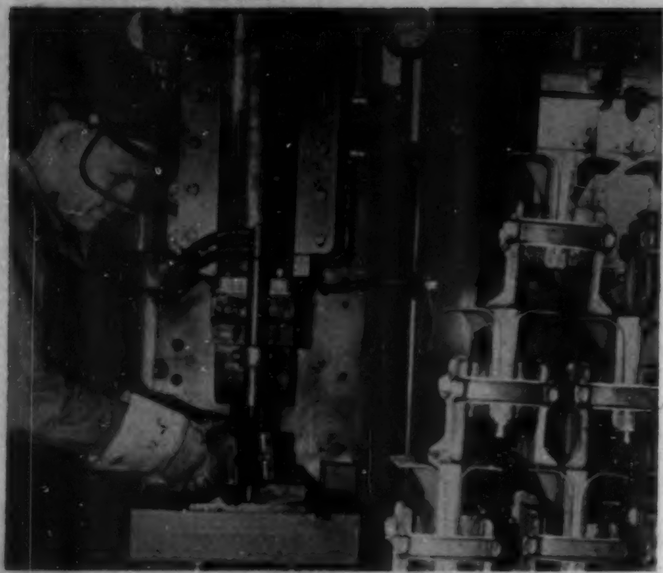
11



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and hand clamps or toggle fixtures. Heating methods that have been successfully used are the same as those employed with the first cement: oven, electrically heated platens, steam heated platens, internal resistance (in the case of steel), radio frequency, infrared lamps or any other method that will give the necessary curing temperature. Resistance of the second bond to oils, fuels, penetrants and coolants is governed by the rubber or synthetic rubber used. The bond with rubber is not resistant to hot, strong alkali solutions. On steel, the second type of cured cement offers more corrosion resistance than most available clear coatings.

The following examples show how Cycleweld is used for the bonding of materials in various combinations:

Metal to metal—One typical item in production is a lengthy wing flap for a fighter plane. This is a case of merely substituting Cyclewelding for riveting in the assembly of Alclad parts of the flap structure. Such substitution eliminates 900 rivets, and the wing flaps are produced very rapidly at a cost saving of 30 to 35 percent. The first type of Cycleweld cement is used, and application is by spraying (Fig. 1), after the metal parts have been chemically cleaned in vats. Coated parts are then assembled and bonded in a press (Fig. 3) with electrically heated platens. Some riveting is required at points not readily reached for bonding (Fig. 4), but the total of rivets used in the flap is only 300, as against the former 1200. The flap is far more rigid and considerably lighter, and tests have shown it to be immune to vibration failure (Fig. 5).

A metal-to-metal bond used to eliminate spot welding is exemplified by Alclad floor sections used in medium bombers.

11—*Close-up of spot welding operation on side straps of ski pedestal. Completed pedestals are stacked at right, ready for painting.* **12**—*After it is cured, pedestal goes to a testing fixture. An air cylinder at 3500-lb. pressure depresses the rubber-mounted part, and perfection of Cycleweld bond is checked visually by means of light in background.* **13**—*Ski pedestal in testing press before pressure is exerted.* **14**—*Now the pedestal is fully depressed at 3500-lb. pressure. The tough assembly, with steel and rubber parts bonded only by Cycleweld cement, is capable of absorbing the shock of a fully loaded transport glider landing on its skis*

13

14

These consist of two thin sheets, one of which is corrugated. Formerly the sheets were joined by the slow and costly method of spot welding; with Cyclewelding, one man with a small 80,000-lb. press can turn out four sections an hour (Fig. 6).

Metal to rubber—This process, using the second type of cement, has been extensively used in producing shock-absorbing ski pedestals for glider landing skis. Thick blocks of Buna S rubber joining metal parts of the pedestal act as a spring. The cement is simply applied to the cleaned metal surfaces by a brush, and toggle clamps having cartridge heaters in the clamps are used to effect the bond to the rubber. From the jigs, the pedestals go to a special testing press where they are fully flexed with a strong light in the background to reveal any possible defect in the bond. Some 3500 lb. of pressure is applied in the test. This is the first successful joining of metal to vulcanized rubber (see Figs. 7–14).

Fiber board—Jettison gasoline tanks for aircraft are assembled by Cyclewelding the two halves of the spherical tank and can thus be turned out at a high rate of speed. (Similar metal jettison tanks still being manufactured are Cyclewelded at the seam, eliminating the much slower and more costly seam welding. The Cycleweld cement acts as both a bonder and sealer, being impervious to gasoline.)

Metal to wood—The important Cyclewashers used in plywood aircraft construction are the best example of present production (Fig. 15). However, this bond is not limited to small parts but can be used to join large areas of metal with wood veneer or plywood.

Plastics to metal—Various (*Please turn to page 152*)

***15**—Wood is Cyclewelded to thin metal washers to form Cyclewashers of $1^1/_8$ to 2 in. diameter, used wherever metal places a load on wood or plywood. When washer's wood surface is Cyclewelded to wood plane part, the load is distributed. **16**—An early step in the development of the new process was the formation of these "tension buttons" by Cyclewelding a $1^1/_8$-in. rubber button to two pieces of laminated phenolic plastics. Rubber tore before bond broke. **17**—The three main sections of these aluminum box beams for aircraft are assembled (right) by Cyclewelding. **18**—Another view of box beam shows how few rivets are needed. **19**—Group of Cyclewelded parts for medium bombers*

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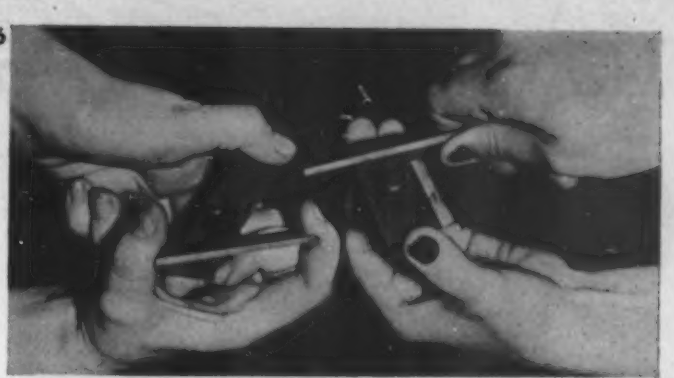

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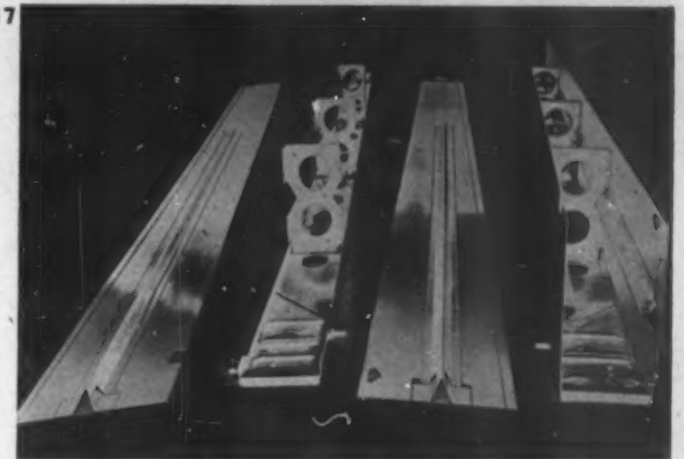

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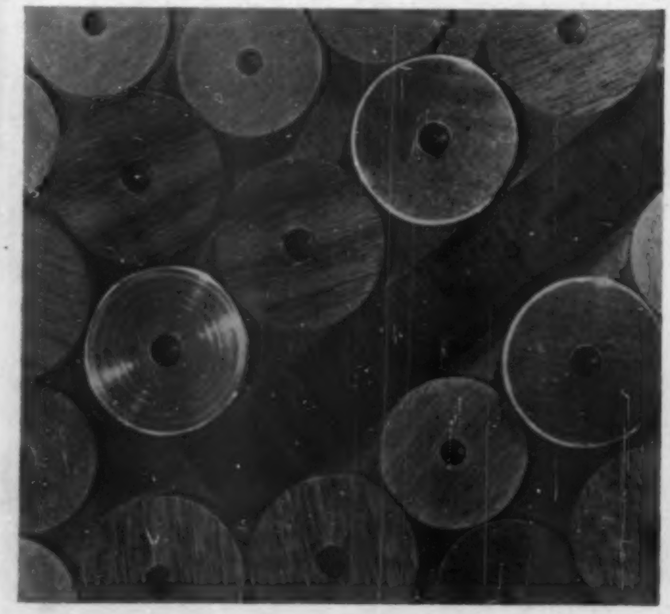

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Navy training bayonet

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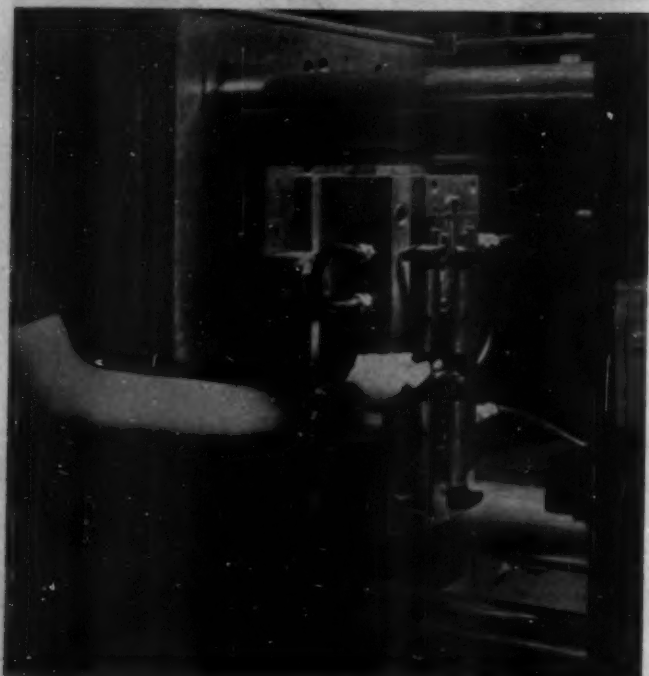

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COLD steel has been a major offensive weapon for a good many years. During the seesaw battle for North Africa, the bayonet in the hands of the intrepid Australians became a nightmare to the Nazis and Italians. The final reduction of last pockets of resistance at Guadalcanal was accomplished by our Leathernecks and their trusty bayonets. The lightning thrust, parry and counterthrust which is taught our Marines was often called into play in these engagements because of the treachery of the Japanese. These yellow fanatics, playing dead dog, would suddenly attack from the rear, and many a Leatherneck's life has been saved due to the great care taken in his instruction in the use of the bayonet. The manual of arms is of equal importance to our sailors: every bluejacket has his rifle and his bayonet as standard military equipment.

Whoever first thought of making the bayonet of anything but steel must be given credit for a great deal of imagination, and constructive imagination at that. Although the name of the person who originated the idea is not known to us, it is a fact that the U. S. Navy and the molding company have co-operated not only to the extent of imagineering a material other than steel, but have succeeded in putting into production a replica of the steel bayonet, manufactured almost entirely from plastics. Designed for drill and parade ground use only, these weapons have released thousands of steel bayonets for service on the fighting front where they will do the most good.

Compression molded of phenolic resin board, this bayonet has the rigidity and general toughness so essential to a weapon of this nature. Its blade can take considerable abuse, particularly as to flexing, before it finally breaks. The bayonet is made up of four separate molded parts: the blade with steel insert, the grip molded in two halves and the guard. A spring clip mechanism assembled into the grip acts as a lock, holding the bayonet in position on the rifle. Depressing this spring clip releases the bayonet.

Figure 1 shows the component parts of the bayonet and the weapon completely assembled. The two grip halves, originally molded from medium impact phenolic material, are now being injection molded in a 4-cavity combination mold (see Fig. 2). A high acetal cellulose acetate gives the required strength and rigidity so necessary in these grips.

Both the guard and blade are made from phenolic resin board. Preforms approximating the shape of the part are blanked out by the raw material manufacturer and supplied to the fabricator ready to mold. The blade is molded from two blanks each weighing 38 grams, which are preheated by infrared lamps in an oven with a temperature of approximately 225° F. The blanks are held on edge by racks holding four blanks each, and a sufficient number of blanks are loaded

1—Component parts of the training bayonet—the blade with steel handle insert (left), 2 grip halves (top and bottom) and guard (center)—are shown assembled at right. 2—Four grip halves are injection molded of phenolic material in this combination mold. 3—High production results in the molding of guards in this six-cavity, flash type mold are due to the fact that the mold does not need to be chilled before the parts are discharged

in the oven so that with the mold on cycle the blanks will be preheated approximately 20 minutes.

Two blanks and the laminated steel handle insert are loaded in each cavity of the mold. One blank is laid in the cavity with the steel insert placed on top of it and covered by the second blank to give a sandwich type of loading (Fig. 4) with the laminated steel insert in the center. Since this insert extends into the molded blade approximately $1^{1}/_{2}$ in., it is securely held in place.

The bayonet blades are molded in a two-cavity flash type mold and, with a molding temperature of 305° to 310° F., cure in $2^{3}/_{4}$ minutes. The parts are discharged hot and at this point, when the job first started, much trouble developed. There seemed to be no way that these bayonets could be kept flat. If they were placed on a table and exposed to a draft, great warpage would result. After much experimenting, special racks were built on which approximately 200 bayonets may be hung, each on a nail by the handle with the pointed end down. After the blade is partially cooled it is removed for breaking off the flask and then rehung on the rack for the final cooling. After this system was devised, bayonets were produced with no warpage whatever. Figure 5 shows one of these racks loaded with bayonets being cooled.

The edge of the blade at the flash point is finished by first passing it lightly over a wet sanding belt, and then giving it a light buffing with rouge on a standard buffing wheel for final finish. Figure 6 shows the buffing operation on the blade after it has been sanded. Before the handle and guard are assembled the blade passes through several gaging operations. Figure 7 shows an inspector carefully checking the blades.

The guard is molded from three blanks, each weighing 5.84 grams and of a thickness to mold 0.125 in. thick. After being preheated in an infrared lamp oven for 20 min., these blanks are loaded in an 6-cavity flash type mold. With a curing time of $2^{1}/_{2}$ min. at 320° F., fairly high production results due to the fact that there is no need of chilling the mold before the parts are discharged. Complete flash removal is taken care of in a trimming die mounted in a (*Please turn to page 144*)

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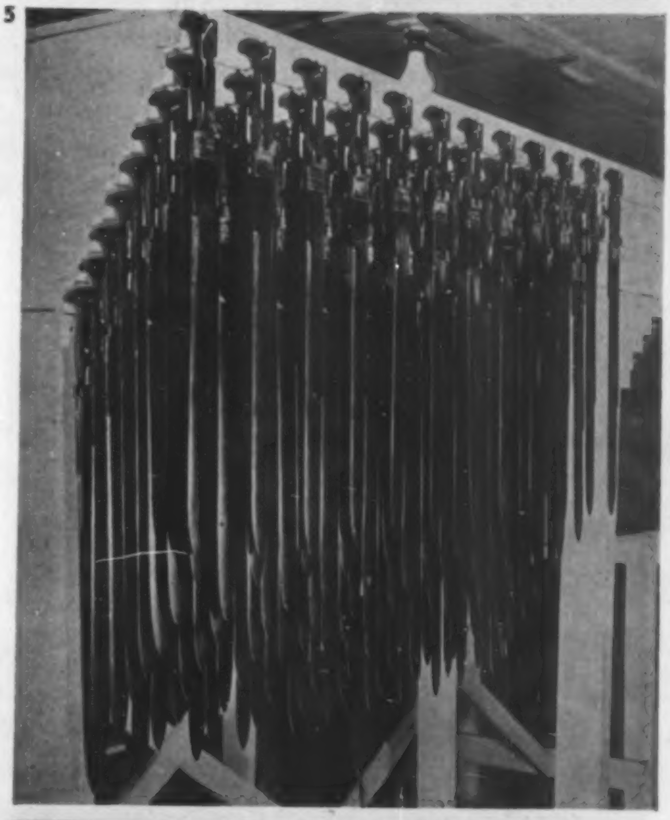

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4—The laminated steel handle is inserted sandwich fashion between two blanks when the mold is loaded, to form the blade of this bayonet. 5—Cooled on these racks, the blades do not warp and bend. 6—As a final finishing operation the blades are buffed. 7—Before handle and guard are assembled, the blades are carefully checked

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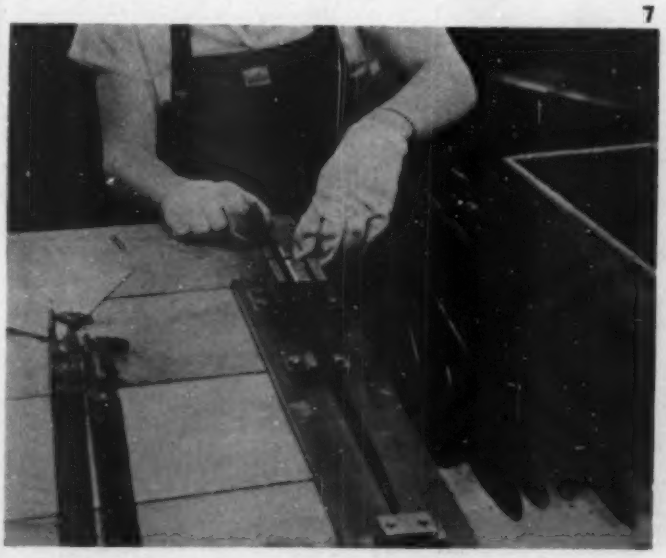


Signal Corps microphone, war model

1

PRESS ASSOCIATION, INC.

1—Sketch pad on knee, this student observer in the "office" of an 0-52 observation plane is using his hand microphone, molded of ethyl cellulose and phenolic, to check with the pilot

If patrol and observation planes, like bombers, had names of their own, chances are that at least one would be called *Snoopy*. The function of these ships is to pry into the doings of Nazis and Japs, take note of what they see, and then go home and tell!

Since the business of gathering and reporting news depends, above all, on perfectly functioning communications equipment, particular care must be taken to see that such apparatus will perform under the severest service conditions. One device which has successfully passed rigid Signal Corps tests is the hand microphone through which the observer (Fig. 1) is checking with his pilot. The manufacturer, Universal Microphone Co., Ltd., has redesigned this piece of equipment, originally made of sand-cast aluminum, for plastics in the belief that a better "mike" could be molded at less expense, and that faster production could be obtained.

The microphone (Fig. 2) is a hand-held, single button carbon device with a press-to-talk switch, consisting of a handle or housing which acts as a connection member for three basic sub-assembled parts: the integral mouthpiece and microphone cartridge, the switch, and the cable clamp—the last a die cast zinc part with supplemental steel stampings. Four West Coast molding companies are currently supplying microphone parts of ethyl cellulose and phenolic, using both injection and compression methods. All of these parts are shown in Fig. 4.

The light grey handle (Fig. 3), which looks somewhat like its aluminum predecessor, is injection molded in a single cavity of low temperature ethyl cellulose. Since the design of the piece was established by Signal Corps specifications, it was not permissible to incorporate changes which might have facilitated molding, such as a concentric arrangement of the handle with the head or other redesigning to eliminate undercuts. Moreover, in the course of developing it in plastics, frequent improvements had to be made to enable the molded handle to meet requirements, among them the incorporation of ribs in the head for added strength and the making of certain sections heavier.

The single-cavity die in which the handle was produced was constructed with several loose mold pieces and loose cores. One of the molding companies reports that it used a booster on its injection pressure to raise it sufficiently for uniform wall structure. Six metal inserts are used in the plastic casting—three to hold the mouthpiece and two to hold the switch assemblies, while the sixth is a bent U bolt molded into the head of the housing. Consequently, care had to be taken in molding to avoid shrink marks.

All parts of the microphone's sub-assemblies are compression molded. The cartridge assembly consists of a button housing, which completely encloses the carbon button, permanently assembled by mounting screws to a mouthpiece. This housing is molding of general purpose phenolic in a 12-cavity mold, while high impact phenolic material forms the mouthpiece, which takes two molds, one of 4 and one of 6 cavities. A condenser forms part of this assembly, and all mountings are locked in place with red wax to eliminate vibration. Three screws fasten the cartridge assembly to the handle, which has three threaded inserts molded-in.

Three molded parts go to make up the switch assembly. The switch button, of high-impact phenolic, is cured in a 6-cavity semi-positive mold loaded with a slide bottom tray. As the mold is opened, buttons are extracted from the cavities by the plungers which mold the threads and are spun off by a high-speed gear device. Complete cycle of loading, curing and extracting is $3^3/_4$ minutes. As the engraving on the button is sunk in the face, mold cavities were hobbed on low carbon steel and can be carburized and hardened to withstand long use. Of the same high-impact phenolic material is the switch body, which takes an 8-cavity die. The center plug, of general purpose phenolic, is formed in a 12-cavity mold.

Severe tests simulating field conditions must be met before the microphones are acceptable. In the manufacturer's test-

ing laboratory, a unit completely assembled with electrical parts and wiring is given repeated drop tests from a height of 6 ft. onto concrete or steel at temperatures ranging from $-60°$ to $+160°$ F. Careful selection of the injection molding compound used has been found essential if the device is to pass the drop test, since impurities in the material will cause fracture early in the test. Flow of material is another important consideration in view of the extremely low temperatures encountered in airplane flight. The molding technique must be closely controlled to secure uniformly dense moldings, or the walls of the housing will crack or collapse under the extremes of temperature.

Operation of the complete assembly has been found satisfactory through the tested temperature range. Rapid changes in barometric pressure and humidity do not affect the characteristics of the microphone, and possible dimensional variations in the handle will not influence the performance of the sub-assembled elements. The redesigned plastic housing, compared to the aluminum, has the advantage of non-tarnishing permanent color, and weighs 2 oz. less. A pistol grip section molded on both sides is another feature gained by the conversion to plastics.

Credits—Material: Handle, Ethocel, molded by American Molding Co. and "T" Die Cast Molded Products. Mouthpiece, button housing and switch assembly, Bakelite, molded by American Molding Co., F. E. Reinhold Co., Western Plastics Molding Co. T-17 Microphone manufactured by Universal Microphone Co., Ltd.

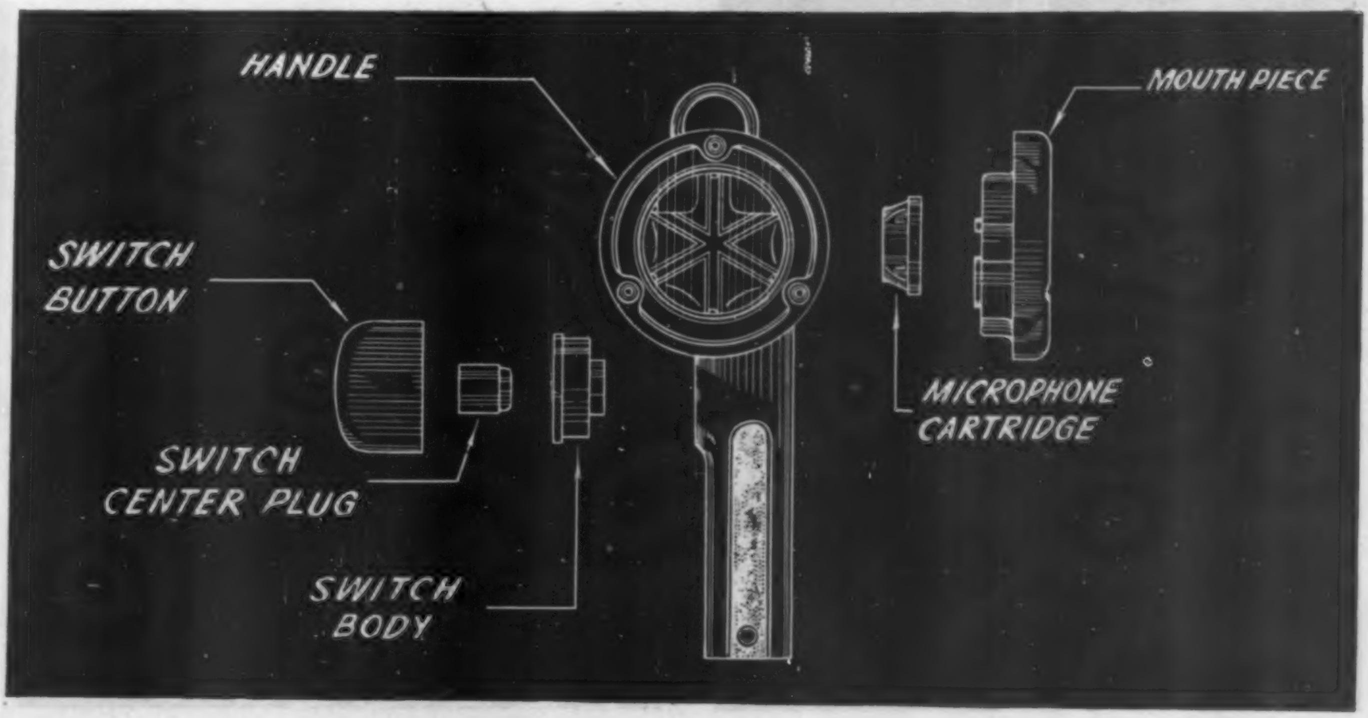
2

3

2—The basic parts of this hand microphone are the handle which acts as a connection member, the integral mouthpiece and microphone cartridge, the press-to-talk switch and the die cast zinc cable clamp. 3—Six metal inserts are used in the single-cavity die in which this handle is molded. Three of these inserts hold the mouthpiece, two hold the switch assemblies and the sixth is a bent U bolt molded into the head of the housing. 4—This blueprint shows all the microphone parts that are molded of low temperature ethyl cellulose and phenolic material

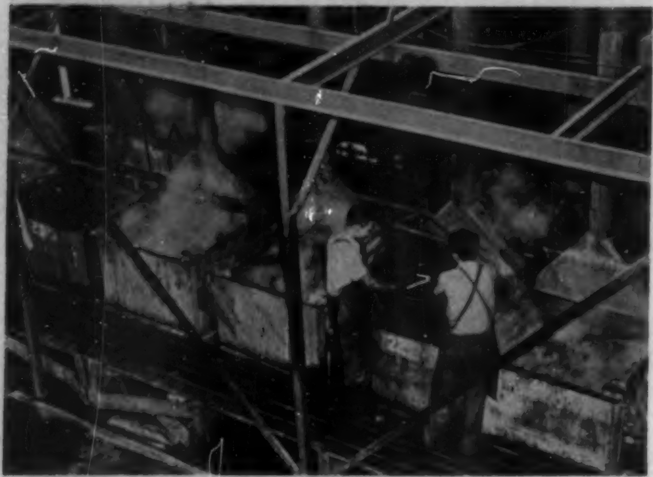
DRAWING, COURTESY UNIVERSAL MICROPHONE CO., LTD.

4



Steel shell case coating

PHOTOS, COURTESY BUICK MOTOR DIV., GENERAL MOTORS CORP.



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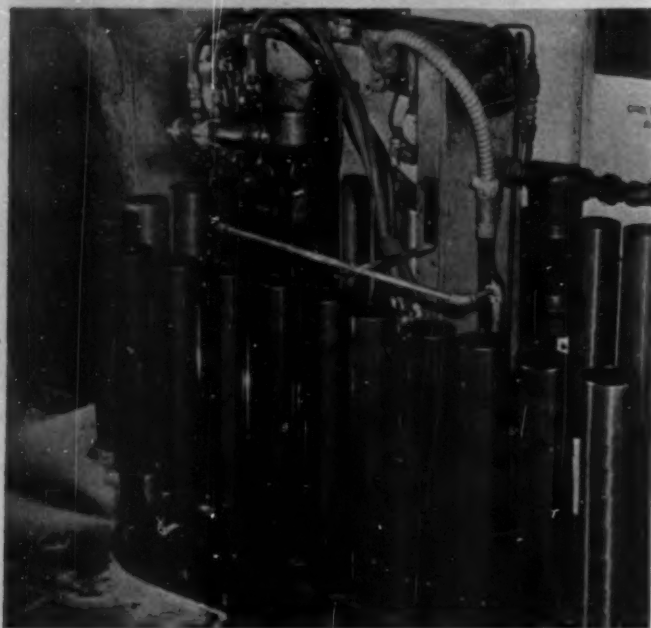

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WHETHER in the air, at sea or on the ground, the conclusive success of a military venture depends upon the weight of munitions that can be thrown against the enemy. It is ammunition that gives body to such campaigns. Today, steel shell and cartridge cases have been widely adopted in place of brass as the vehicles of this destruction. Contributing to the success of these cases is the final coating of phenolic resin which protects the steel shells against corrosion and sparking.

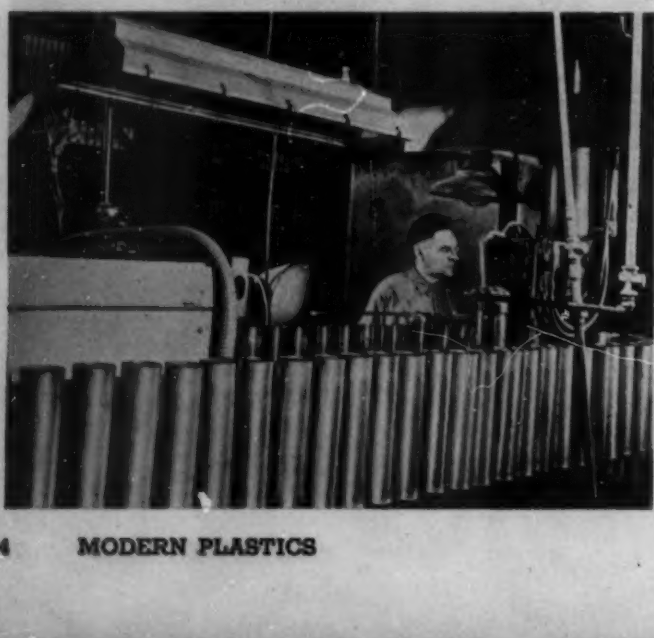
In the typical mass production of the important 75-mm. steel shell cases, the cases first are given a phosphoric acid pickle which provides a bond for the unpigmented baked phenolic varnish, and some additional protection against corrosion (Fig. 1). The entire coating operation is fully automatic. The cases, open end up, are mounted vertically on a conveyor and rest on fixtures attached to the conveyor chain. This arrangement makes it possible for them to be spun about by a motor-driven belt as they pass the spray nozzles. One spray nozzle is mounted on a traveling arm which descends inside the case and lifts out again at a uniform speed, directing a mist of varnish over the interior surface of the rotating case. At the same time, outside nozzles are positioned to coat the base and wall thoroughly and uniformly (Fig. 2).

After painting, the cases move slowly between 2 banks of infrared lamps, 64 lamps to each side. The conveyor loops twice at the end of the lamp bank so that the cases travel through the heat zone 3 times. This baking operation requires 48 min. in a temperature of approximately 360° F. (Fig. 3). Before passing to an unloading station where they are thoroughly dry and cool enough to handle, the cases pass through an exhaust cooling hood.

In some plants, the varnish is applied by dipping. The only difficulty with this process is a tendency of the varnish to gather in a bead at the mouth of the shell. This condition is corrected by having the shell cases pass on overhead conveyors over a "detearing plate." (*Please turn to page 156*)

1—Steel shell cases are given a phosphoric acid pickle before spraying with phenolic resin varnish. 2—Close-up of fixture which automatically coats cases. 3—After coating, the cases are conveyed 3 times through a double bank of infrared lamps. 4—Dipped shell cases pass over a "detearing plate" which pulls beads of varnish off their mouths

3



PHOTO, COURTESY POPULAR SCIENCE MONTHLY

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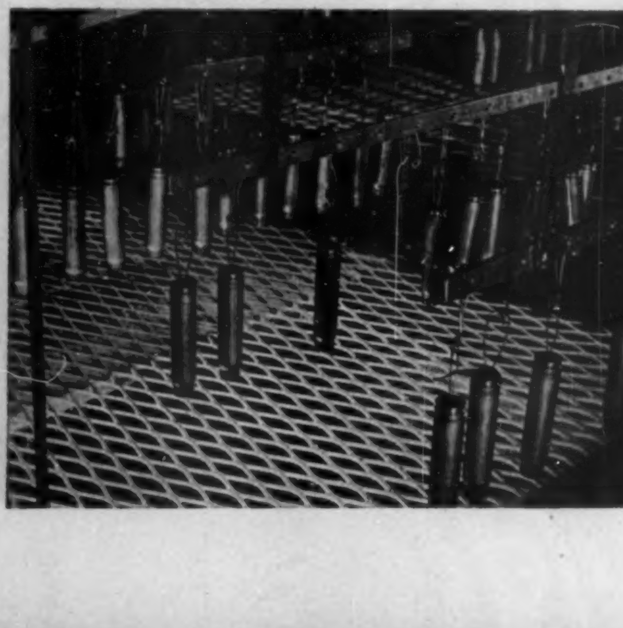

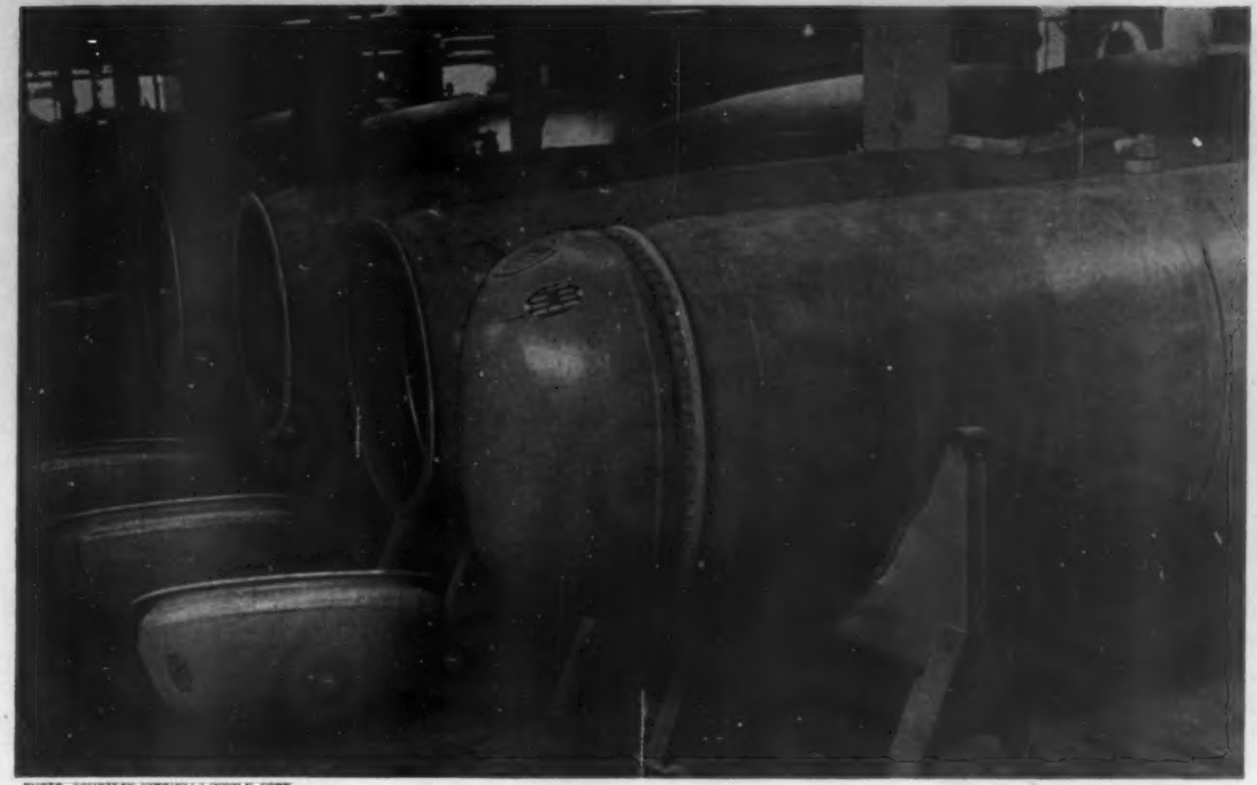

PHOTO, COURTESY VIRGINIA-LINCOLN CORP.

1—These 300-gal. plastic jettison tanks are molded in 2 pieces of urea-impregnated canvas and cloth. In the final assembly the nose is bolted to the body with 56 stop nuts to provide a vibration-proof assembly

Jettison tanks for ferry service

COMMITTED to a policy of bringing the Axis to the point of submission by air attack, our planes are probing deeper and deeper into enemy territory. The industrial Rhur Valley, the war plants of southern Germany and the production centers in northern Italy lie in ruins as a result of long-distance aerial pounding. American and British planes have flown 2400 miles from North African bases to devastate Ploesti, Rumania's richest oil fields, across the Mediterranean again to bomb the transportation hub at Rome, 1400 miles to hit the Axis heart at Berlin.

The success of this entire policy depends on Allied ability to maintain air superiority, which means planes and more planes. The American war factories can turn out the airplanes but the next problem is to get them to their destinations as quickly as possible. Fuel is the principal problem in carrying out this form of transportation. The installation of larger permanent tanks does not solve the problem, for the additional weight would in itself reduce range. The answer has been a jettison tank, one that can be dumped from the plane when its contents are consumed. Today, it frequently is a plastic tank of this type that provides the gas capacity, the vital saving in weight and the added range that brings the American bombing and fighting aircraft directly to the front lines.

The largest plastic jettison tank so far constructed is a 300-gal. unit (Fig. 1) designed originally for use on a Glenn L. Martin bomber. Employing urea-impregnated canvas and cloth, the tank is molded in 2 pieces—the body and the nose—with the nose bolted to the body with 56 stop nuts to provide a vibration-proof assembly. The tank, elliptical in shape, measures 149 in. in length and approximately 32 in. in diameter. It is suspended on the bottom of the wing between the engine nacelle and hull. Gas is transferred to the permanent supply tank by a small pump bolted to the outside of the assembly and covered by a fairing to reduce drag.

Plastics originally were adopted in an effort to conserve metal. However, when produced in large quantities these urea-impregnated glass fiber cloth or canvas tanks also effect a saving in cost since there is no spot or seam welding nor complicated assembly. Through the use of low pressures and low temperatures in the molding of these jettison tanks, die costs too are kept to a minimum.

The molders of this tank treat their own cloth and the first step at this plant is the impregnation of the material. Bolts of glass fiber cloth and other fabrics are unrolled slowly into a urea resin bath. When the material is thoroughly saturated, it is fed between rollers that squeeze out all excess resin, which is returned to the bath. The glass fiber cloth next is sent through long ovens to drive off the volatils in the liquid resin. Supported by chicken wire instead of by conventional conveyor rolls, the material is heated for about 8 min. at 140° F. The resin then is partially polymerized and no longer tacky. Following this drying, the reinforced cloth is cut in patterned shapes to fit various areas of the jettison tank. Practice in this operation follows closely that employed by clothing manufacturers in cutting patterns for dresses and suits.

The molding of the body and end piece of the jettison tank

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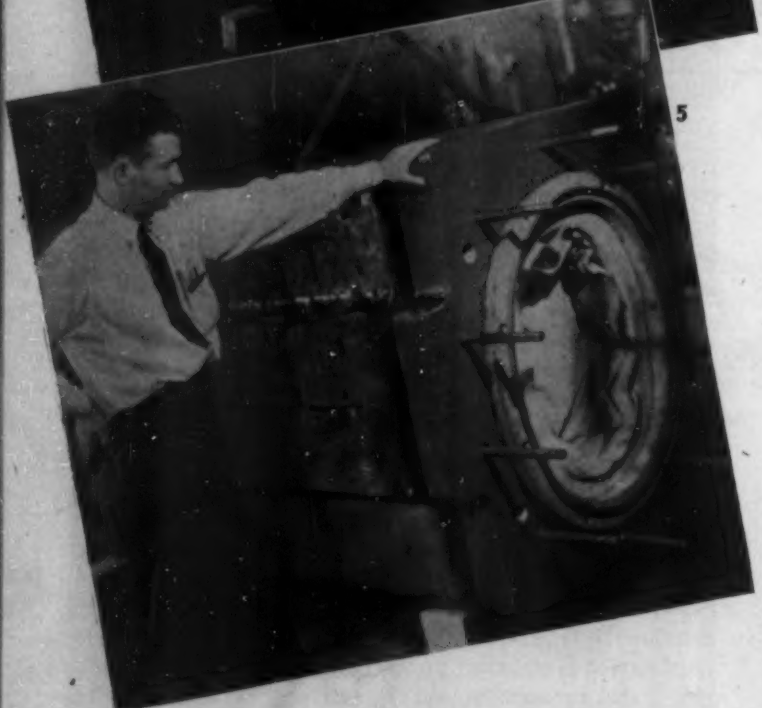

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ALL PHOTOS, COURTESY VIRGINIA-LINCOLN CORP.

2—The preform of the jettison tank, with wooden form removed, is ready for insertion in the mold. 3—The preform, wrapped in cellophane to prevent the material sticking to the mold, is placed in the lower half of the wooden mold. 4—The upper half of the mold is lowered with chain hoists preparatory to being bolted to the bottom mold section. 5—The end plate is lowered into position

are essentially the same. In the case of the body of the tank, a rubber bag first is slipped over a wooden form shaped like the part to be molded. Since rubber and the reinforced fabric have a tendency to stick together when subjected to heat and pressure, the molders of these tanks have adopted the practice of separating these 2 materials with a layer of cellophane. After the cellophane has been laid over the entire surface of the rubber bag, the patterned pieces of impregnated cloth are wrapped around the form. Additional layers of the material are added to areas of particular stress for reinforcement. Instead of using the conventional staples to hold the impregnated material in correct position on the wooden mandrel, this company has adopted a hot spot tack welder. A low heat soldering iron is touched to the wrapped cloth at the points needing support. The heat serves to complete polymerization at these small spots, resulting in firmly welded anchors. So that the impregnated material will not stick to the exterior wooden die when subjected to heat and pressure, the same practice which prevents adherence of the fabric to the rubber bag is followed. Again a layer of cellophane is wrapped around the entire form.

As a final step before insertion in the mold, the wooden form upon which the material has been built up is slipped out from the center of the preform, care being taken that the rubber bag remains in place. At this stage the preform consists of the reinforced material in approximately the correct shape of the finished piece, protected inside and out with layers of cellophane, built around the rubber bag (Fig. 2).

The cellophane blanketed form next is placed in the lower half of the split mold, which is made of wood (Fig. 3). This mold conforms exactly to the outside dimensions of the jettison tank body with one end open to form the entrance hatch. In the final assembly the tank cap is bolted to this opening to form a gasoline-tight unit. With the preform in position, the upper half of the mold is lowered with chain hoists (Fig. 4) and bolted to the bottom section. An end plate then is slipped over the open end of the wooden mold. This plate has an opening cut in its surface to correspond with the open end of the tank (Fig. 5). The mouth of the rubber bag and the edges of the reinforced material are carefully pulled out over the rubber gasket which surrounds this end plate opening to form a flange. This opening then is closed by means of a solid, flat plate which when bolted into position makes a pressure-tight seal (Fig. 6).

Steam pressure of approximately 25 to 50 lb. is introduced into the inside of the rubber bag through a nozzle in the end plate of the mold. Under this pressure the impregnated woven glass fiber cloth or impregnated canvas is forced

against the walls of the wooden mold. As a result the exterior surface of the jettison tank is perfectly smooth, all surface irregularities due to extra layers of cloth at points of stress appearing on the interior of the assembly. The steam gives the two elements necessary to the polymerization of the urea resin, namely, heat and pressure.

After the body of the tank is removed from the mold, the cellophane blanket peeled off and the rubber bag withdrawn, the part is taken to a finishing and assembly room. Here various fittings including inlet and feed pipes are inserted. Large bulkheads or anti-slosh baffles are glued inside the tanks with cold-setting resins (Fig. 8). Spaced at regular intervals across the body of the tank, these partitions prevent the gasoline from surging unimpeded from one end of the tank to the other. If allowed to flow at will during a flight, the fuel would be thrown against the ends of the jettison tank with great force, endangering not only the tank structure but the stability and maneuverability of the plane. The baffles with holes cut out at center and sides reduce the turbulence of the gasoline without reducing the necessary flow to the feed pipe. These bulkheads also serve to reinforce the tank at the points where it is supported on the exterior by slings in the bomb bay of the plane. Work on the inside of the tank body is simplified by the fact that the aperture is large enough for a man to enter.

The molding of the tank cap or nose section follows closely the procedure used in forming the body, with the wooden form, rubber bag, 2 layers of cellophane and patterned pieces of urea-reinforced fabric making up the preform. Steam again is used to produce the heat and pressure that effect polymerization of the resin and give form to the part in the final wooden mold. The flange on the body of the tank to which the cap is bolted is convex in shape. To provide a firm seal, the shoulder flange of the cap is concave. The holes for the 56 stop nuts which join the cap and body of the jettison tank to make a vibrationproof assembly are drilled in a finishing operation after molding is completed. As a final step the units are covered with protective, coatings.

When a plane pulls out of a dive terrific pressures are set up in all its parts. This is particularly true of dive bombers but all planes are subject to similar strains in violent maneuver to evade enemy fighter attack. Gas tanks are not immune to these sudden pressures and jettison tanks must have strength to withstand every possible demand. When these jettison tanks went into production, the first units were subjected by the company to (*Please turn to page 156*)

6—The mouth of the mold which corresponds to open end of the tank is closed by this solid, flat end plate which when bolted into position makes a pressure-tight seal. 7—In this structural test the tank was loaded with 15,000 lb. of lead and suspended by slings. 8—Large bulkheads are glued inside the jettison tanks at regular intervals with cold-setting resins to prevent gasoline from surging unimpeded from one end of the tank to the other. The pipes in the foreground are inlet and feed connections. 9—To test for leakage, fuel is pumped into each jettison tank before shipment and a pressure of 4 p.s.i. applied

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Product Development

Industrial light reflectors

At the present time there exist in industry two conflicting desires with regard to illumination: for maximum artificial lighting and for minimum consumption of electric power. In an effort to bridge the gap between these 2 objectives, urea-formaldehyde is employed in the molding of the reflector for this industrial lighting fixture. Tests conducted by Electrical Testing Laboratories show that the reflector not only gives 86 percent of light from the bare bulb but directs 75 percent down on the work and 11 percent toward the ceiling.

The urea-formaldehyde, supplied in granular or fine powder form, is molded in steam-heated steel molds in 10-min. cycles at temperatures between 280° and 330° F. and under pressures of from 1000 to 1200 tons. Light-weight and shatter-resistant, this industrial reflector uses only 13 oz. of steel in its entire assembly.

Credits—Material: Plaskon. Molded by General Electric Co. for F. W. Wakefield Brass Co.

Transparent piston caps

A completed airplane every $4\frac{2}{3}$ minutes is our production goal for the Fall. Contributing to this speed-up are the methacrylate adapters with steel inserts used to protect the threaded ends of airplane landing gear pistons during plating. With plastic caps the plating requires but 6 hr. compared to the 12 hr. needed when steel guards were used.

There are several reasons for this cut in production time. Use of the metal protecting caps, stopped off with lacquer to prevent plating, made it difficult to throw the chromium against the shoulder at the bottom of the piston. As a result, in order to provide a finish grind surface at the base, it was necessary to overplate the top of the piston .003 in. or more. This not only added 3 or 4 hr. to the plating time but necessitated longer grinding at the piston top.

Methacrylate guards were adopted when tests proved that the plastic withstood all cleaners, acids and the plating bath without signs of deterioration, and that it did not "tree." With these new guards, threaded steel caps first are screwed over the piston threads. The adapters fabricated of methacrylate tubing then are slipped on top of these metal caps to form a shield level with the top of the piston flange. Since the plastic guards permit correct plating next to the flange without overplating at the top, both plating and grinding time are saved.

Credits—Material: Lucite. Fabricated by Curtiss-Wright Corp.

Soundproofing a pump

When grating noises and disturbing vibration in the air conditioning system started a barrage of complaints by tenants of a western office building, engineers immediately sought the source of the commotion, and established the metal gears in the refrigerant circulating pump as the noisy offenders.

These pumps they redesigned, using a laminated fabric phenolic bonded plastic in place of the noisy cast iron. The plastic was chosen not only for its value as a nuisance abater, but because it would withstand the circulating action of methyl chloride which goes through the refrigerating compressors at the rate of approximately 90 lb. discharge pressure and 25 lb. suction pressure.

The finished gear, 20 in. in length, is an assembly of four 5-in. segments of the plastic material, 8 in. in diameter. Each pair of sections locks together by undercuts and is keyed to the shaft. The gears are held in position longitudinally by collars which nest into recesses machined into the ends of the gears. The gears are of standard involute tooth form having 18 teeth to the section with $2^{1}/_{2}$ normal diametral pitch of a $14^{1}/_{2}°$ pressure angle. Pitch diameter is 7.6 in. and outside diameter 8.4 inches. Lead error is .0002 per in. of face.

The gear hobber operates at a low speed which serves to reduce the amount of heat generated and eliminates the need of a coolant, permitting exacting tolerances in the finished parts. In addition to reducing by about $^{1}/_{3}$ the time taken to machine metal gears, the laminated fabric phenolic bonded gears weigh only 40 lb. as against 225 lb. for the cast iron parts previously in use. This weight differential of course, results in decreased inertia and lower horsepower input.

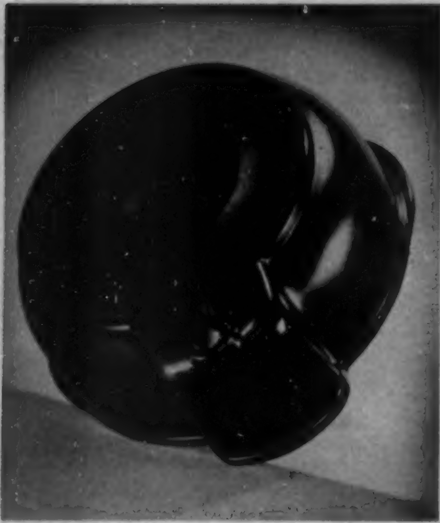
Credits—Material: Micarta. Fabricated by Johnson Gear & Manufacturing Co.

Synthetic rubber lining

A military supply dump means danger. To minimize the hazards of possible bombing or sabotage, the Navy is moving its gasoline and fuel oil storage tanks underground where they will be indistinguishable from the air and practically invulnerable to fire.

One of the problems presented by prestressed, underground concrete tanks was that of protecting the less viscous fuels such as Diesel oil and aviation gasoline from a drop in octane rating resulting from their exposure to the alkalies present in concrete. A solution for this deterioration was found in thin sheets of polysulfide synthetic rubber applied like wallpaper to interior walls, floors and columns. This lining also reduces the formation of gum on gasoline and prevents loss by seepage through the porosity of the walls.

The lining comes in sheets 38 in. wide and in thicknesses of .025 and .03 in. The front surface of the sheets is smooth except for a 3-in. strip along one side which, like the back, is roughened to provide better lap adhesion. Before affixing the lining all holes in the concrete surfaces are filled and projections removed. The walls then are given 2 coats of synthetic rubber cement, the sheeting one coat. The work of hanging is begun at the top of the interior wall, each strip overlapping the next by 3 in. with a 6-in. overlap onto the floor. Next the areas around ladders and other protuberances are covered, and the floor is lined.



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1—Molded of phenolic resin in a shape which can be turned in a lathe, this cream separator supply bowl meets the demand for low cost. 2—This view shows the inside of the bowl. 3—The raised spacers on these skimming disks are punched out after the parts are molded

Molded dairy equipment

THERE are approximately 25 million cows in the United States. Last year they produced enough whole milk to form a lake 75 miles long, 150 ft. wide and 31 ft. deep. Converted into butter, cheese and dried milk, this yield is an important factor in the physical wellbeing of our fighting forces, our civilian population and that of our Allies.

The chief problem in producing these essential commodities hinges on two conflicting factors: loss of manpower in the dairy industry and lack of adequate transportation. In order to relieve large creameries of the work of handling whole milk and at the same time to reduce the strain on transportation, the Government has set quotas for the production of individual cream separators. By the use of these home units, milk can be separated from the cream before shipment thereby slashing the gallonage that must be transported.

With a monthly schedule of 500 separators, one manufacturer turned to plastics for its supply bowl (Figs. 1 and 2), skimming disks (Fig. 3) and disk holder. The material requirements for dairy equipment are very severe. It must be odorless and impart no taste to the milk or other substance which might be put in the machine. The U. S. Dept. of Agriculture recommends that separator parts be washed in soapy water and sterilized in water heated to 212° F., then left in the sun to dry. In addition to resisting such temperature changes and having low water absorption, the material must resist alkalis and washing compounds and have an impact strength sufficient to withstand ordinary handling.

For the supply bowl (Figs. 1 and 2) into which the whole milk is poured and from which it flows to the separating compartment, phenolic resin was found to be most successful. Both the material and the shape of the bowl, which can be turned in a lathe, were dictated by a desire to keep down costs. The part is molded in a cast-steel lined cavity under 1250 tons pressure; cavity block and punch are channeled for heating.

The actual cream separation is performed by the disk holder and cone-shaped disks. The holder, $4^3/_{16}$ in. high with a base diameter of $3^1/_4$ in., is injection molded of ivory polystyrene.[1] Fitting on a vertical, revolving shaft, it supports an average of 25 disks stacked on top of one another cone fashion and held slightly apart by little raised spots or spacers molded in their top surfaces. There is sufficient room between the disks to permit the passage of a thin layer of milk. The centrifugal force of the bowl, which revolves at 7500 rpm., separates the whole milk particles. The cream or fat particles which are lighter are thrown by the spinning disks toward the top of the stack where they slip between two of the disks and out into the proper receptacle.

Formerly these disks were made of stainless steel or of carbon steel, tinned to prevent rusting. It was found that tin soon wore off, making the disks unusable. The stainless steel was both expensive and hard to form. Both metals had the disadvantage of creating a certain amount of weight in the separating bowl. Since it is necessary to maintain the bowl in perfect balance in order to rotate it at 7500 rpm. and achieve efficient skimming, this extra weight proved a liability. The new light-weight plastic disks not only solve this problem but simplify the making of repairs.

The principal problem in molding these skimming disks was to achieve a wall thickness of not more than 0.025 to 0.027 in. and at the same time maintain sufficient strength to withstand ordinary handling. Thicker disks would limit the number that could be used in each machine and reduce the skimming capacity of the separator. Resin treated paper is used for the cones. It has sufficient plasticity to fill out the raised spacers that hold the cones apart. Since the fillers used in this part do not permit bottom and side openings to be cored out in the mold, these holes are punched in the disks after their removal from the 4-cavity die. As with the other plastic materials used in this separator, the molded resin-treated paper withstands washing in soapy water, sterilization in boiling water and sunning.

Credits—Material: Textolite. Molded by General Electric Co. for Galloway Co., Inc.

[1] See MODERN PLASTICS *20* 73 (May 1943

Laminated aircraft sub-assemblies

A COMPREHENSIVE report on U. S. air transport issued recently by the O.W.I. presents the magnitude of today's aircraft industry in terms that every citizen can understand. The 1943 production total of combat and cargo planes, it discloses, will reach a figure which represents one-fourth of the annual war budget and nearly one-seventh of the estimated national income.

Although it is easy to be bullish in predicting the postwar possibilities of an industry built to such proportions, the Civil Aeronautics Administration, among others, cautions against extravagant claims for the future of air transport, citing high cost per ton-mile and refueling problems as deterrent factors. On the other hand, it points to the air-mindedness of the men connected with wartime aviation as an impetus to the building up of a worldwide system of peace-time air traffic.

The world of the airplane embraces those who build the ships as well as those who fly them, and the plastics industry, with its increasingly large stake in plane construction and equipment, can be expected to contribute in proportion to the 500,000 planes that the C.A.A. expects to see in the air by 1950. Alert to the potentialities of postwar applications in the aeronautical field, plastics companies today are doing much of their research and development work along war lines that will eventually be peace lines, and producing for fighters and bombers parts and fitments that will some day serve cargo ships and transports.

One western company, formed for the express purpose of developing plastics for aircraft use, has perfected a low-pressure method of molding its own laminated plastic material into such items as pilot seats, wing tips, heater brackets, observer's dome rings, fuel sight gage guards and escape hatch wells. The material has been tested by the Army Air Forces and the company is now turning out some of these sub-assemblies for trainers, bombers and combat planes and completing mold work for others.

Material for most of these parts is a cotton duck fabric, impregnated with urea-formaldehyde resin and dried under rigid temperature and humidity control. Although no set of the resin occurs at this stage, the control is extended by storing the processed fabric until needed in vaults refrigerated at 40° F. On a steel bed fitted with a roller and die cutting knives, the fabric is then cut into specified patterns.

For certain applications, phenol-formaldehyde is used as the impregnating agent, and glass fiber, paper or jute as the filler. In addition to manufacturing its own plastic laminate, the firm purchases laminated phenolic sheets which it reheats and bends to shape in conformance with a technique developed and licensed by North American Aviation, Inc.* It is also working on a no-pressure system by which coating resins are

* See "Thermoelastic C-Stage Laminates," MODERN PLASTICS *20*, 69 ff. (June 1943).

1—A completed pilot seat, one of many items molded of laminated plastic material using low-pressure molding methods. 2—Working in pairs, girls build up a pilot seat to specified thickness by laying cut patterns over a wooden form to the approximate shape of the finished piece. High tensile rope and plastic-impregnated poplar stiffeners are incorporated at this stage. 3—The upper half of this mold which is of the electric hoist, fast closing type, is a steel pressure chamber which lowers over a steam heated steel base to which a positive chrome-plated cast bronze die is attached

2 ALL PHOTOS, COURTESY KING PLASTICS CORP.

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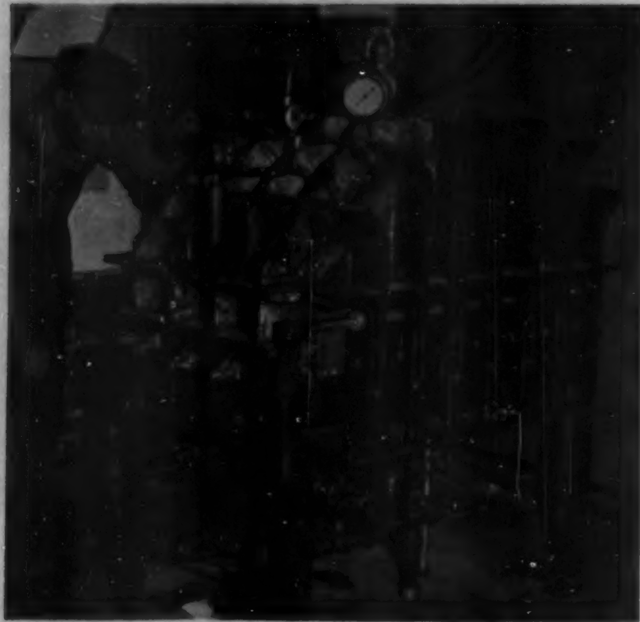

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applied to fabric layers and the product cured without pressure over wooden forms.

The method of molding the sub-assemblies, although it varies in certain details for each particular shape, follows in the main an established routine. The cut patterns which compose a given unit—the pilot seat, for example—are built up in layers of specified thickness over a wooden form to the approximate shape of the finished piece (see Fig. 2). Such structural auxiliaries as high tensile rope and plastic-impregnated poplar stiffeners are incorporated at this stage. This preforming is done by girls, working in pairs and using a hot spot tack welder to speed the process.

The mold used for curing the pilot seat (see Fig. 3) is of the electric hoist, fast closing type. The upper half is a steel pressure chamber which lowers over a steam-heated steel base to which a positive chrome-plated cast bronze die is attached. Over the die, which duplicates the wooden form on which the seat patterns were preformed, a specially designed rubber diaphragm is fitted to serve both as pressure sealer and as a platen bearing on the surfaces not in contact with the positive mold. Securing a fast seal around the flange and gasket was a problem at first, but was satisfactorily solved hydraulically before production runs began.

Pressure used are medium low—from 150 to 225 p.s.i.—molding temperature is 220° F. and curing time approximately 30 minutes. Finishing operations include buffing, painting and attachment of necessary fittings. Use of the flexible rubber diaphragm permits variation in the cutting and arrangement of the patterns going to make up the seat. Thus extra reinforcement can be given at certain points, or special pads incorporated without changes in the die.

Strength, weight and other characteristics of laminated sub-assemblies molded by this method vary, naturally, with the resin-filler combinations used. Those consisting of urea resin with a cotton fabric filler have a tensile strength of 10,000 p.s.i., compressive strength of 20,000 p.s.i., flexural strength of 15,000 p.s.i. and a specific gravity of 1.38. Water absorption (24-hr. immersion) is less than 2 percent. The product is, like other laminates of its class, resistant to corrosion, immune to brine, oil, common solvents and most acids and simple alkalies, light in weight and fire resistant.

A training plane wing tip of monocoque design now in process of development is also of urea-impregnated cotton fabric, molded in one piece. A band of aluminum is then placed around the periphery where attachment is made to the wing proper, and a short strut set part way up the center of the tip. *U*-beam ribs are molded into the unit for stressing and stiffness. The laminated tip weighs 11 pounds.

The mold used for the wing tip has upper and lower welded steel steam chambers with aluminum inserts in both halves (see Fig. 5). Top of the mold is stationary and the lower half is operated by pneumatic pressure to open and close the mold. A rubber bag made especially for this mold is inserted between the two halves of the tip which, like the pilot seat, have been built up on a wooden preform.

(Please turn to page 144)

4—The pilot seat is molded here under pressure of from 150 to 220 p.s.i. at a temperature of 200°F. 5—This open view of the wing tip mold shows the aluminum inserts used in both the upper and lower welded steel steam chambers. 6—These two brackets, used to support heaters in bombing planes, are molded of urea laminate. 7—The low-pressure method likewise is used to mold this airplane part, a laminated bomber observation dome ring

Victory garden insect spray

The importance of Victory gardens was given new emphasis by the recent prediction that the battle for food will last for 2 years after peace is declared. To insure maximum yield from each plant, this spray is designed to wage a relentless fight against omniverous insects. Made entirely of non-critical materials, it uses the household Mason jar as its basic container

THE home garden program has necessitated an increase in the production of many items essential to the success of even the most modest agricultural efforts. Plastics have made inroads in this field as hose couplings, garden hose and spray nozzles in a variety of designs. Among the most recent implements to appear for the Victory garden is a bug spray of the constant delivery type. Every piece of this spray is made of plastics and non-critical materials which are proving fully as durable or even superior to the original metal parts.

The spray consists of a heavy treated-paper tube which resists wear and prevents loss of compression. A valved plunger is operated in the barrel by means of a wooden handle and piston rod. The spray head is assembled from 3 injection molded plastic parts. The first is a cap with a screw thread for fastening the spray to any Mason jar or similar standard bottle which holds sufficient material to avoid the need for too-frequent refilling. The pump screws into another cap mounted at right angles to the jar which holds the spray solution (as shown assembled above). The third injected part is the spray tip, which is specially drilled to produce an atomizing effect by breaking up the solution into thousands of particles which reach under leaves and thoroughly cover all the inaccessible places where garden insects lurk. A plastic tube extends from the cap assembly into the jar, and leads the solution to the nozzle. The nozzle may be easily removed for cleaning, if necessary. The caps are produced in a 4-cavity injection mold (see Fig. 1) while the nozzles are made separately in another mold on a smaller injection machine.

By pumping the handle of the spray gun, a constant pressure is maintained on top of the solution in the bottle so that a uniform spray results which is more or less independent of the action of the pump. Thus the spraying action is continued even while the pump handle is being withdrawn for another pressure stroke.

Although very close tolerances are maintained on the threads of the upright plastic cap, a gasket is used between the pump barrel and the cap to ensure an airtight fit. It was found that a fairly hard grade of plastic was required to prevent the pressure built up in the jar from forcing the second cap off the comparatively rounded threads found on the standard commercial jar. To maintain a tight, permanent seal between the bottle and the spray, it was necessary to use a tough, non-expanding plastic which would resist softening in summer heat. A medium hard grade of cellulose acetate butyrate was found to be the ideal material.

The plastic and other material used in these sprays are not affected by the various chemicals in the insecticides. There is no danger of corrosion plugging the fine openings in the atomizing nozzle. In the event that these particular garden implements are left exposed to the weather, the sprays will not rust or tarnish; nor will they be rendered inoperable by other careless handling. However, *(Please turn to page 144)*

PHOTOS. COURTESY TENNESSEE EASTMAN CORP.

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1—Spray caps, 2 each for Mason jar and plunger barrel, produced of cellulose acetate butyrate in a 4-cavity mold

PLASTICS

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1 For the transmission of military messages where the use of radios is inadvisable or impossible, dependence is placed on carrier pigeons. So that these messengers may put every ounce of their energy into speed, light-weight cellulose acetate message capsules (right) are being fabricated by Lusteroid Container Co. to replace aluminum containers (left)

2 On a moonless night, sound is a poor indicator of the size of an approaching plane. This transparent Lucite light cover, molded in a 2-cavity semi-automatic mold by American Insulator Co., is designed to fit into the edge of a Glenn L. Martin B-26 wing tip over the clearance light. The piece is thick at the ends for the location of dowel pins and has a groove all around the edge to accommodate a continuous rubber tubing applied with acryloid cement and used as a seal. Removal of flash, the drilling of side holes, polishing and buffing comprise the finishing

3 If blood plasma is to mean life to thousands of our soldiers and sailors, it must be kept free from contamination. This closure, molded of Durez by Terkelsen Machine Co. for Plastic Products Sales Co., has passed strict tests given by the medical branches of our armed forces and been found to have no effect on blood plasma when in contact with it. The material also has excellent chemical and water resistance, and gives a very high-gloss finish

4 As a Vought-Sikorsky Corsair closes for the kill, all guns blazing, ejected shells strike the underside of the wings with tremendous force. To withstand these blows, the fairings used as protective covers for the wing flaps were redesigned. Molded of Textolite cotton-filled high impact material by General Electric Co., the side walls were strengthened, adding 1/16 in. to the bottom wall. The radii on the side ribs were enlarged and a back rib added. The small fairing weighs 3.38 oz. The 4.40-oz. aft fairing has a reinforced wall casing around the front edge and a molded vent to prevent water absorption by the plastic

5 An addition to the long list of non-structural plastic airplane parts is this pilot's relief tube and funnel molded by Columbus Plastics Products, Inc., for Curtiss-Wright Corp. The funnel, injection molded of Tenite II, replaces a similar aluminum part, while extruded vinyl copolymer takes the place of rubber in the tubing. This redesign has effected a saving in weight, machining and assembly time

in REVIEW

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6 Partial deafness constantly threatens our industrial workers as a result of noisy machines. An employee at McClellan Field molded the ear plug (left) of transparent Plexiglas which, when inserted in the ear (right), substantially reduces all sound. The inexpensive plugs are invaluable to airplane pilots, test block workers, mechanics and foremen

7 Military photography is demanding—both of men and materials. To carry film for specialized work of this type, dependence is put upon sturdy, light-weight spools molded of solvent-resistant Plaskon. Available in a wide range of colors, this material is impervious to chipping, rusting and corrosion

8 It is upon such small parts as these that our production of vital rayon depends. Molded of Durez by the Auburn Button Works, Inc., these small pulley wheels and the thread-advancing reels for rayon spinning machines have high chemical resistance to both alkalies and acids, offer a long-wearing surface, and may be sanded, machined or buffed without damage

9 Extruded rod and ribbon is being put to good use by the Modern Plastic Co. The 11/2-oz. handle for a parachute cabinet (top) is assembled from 2 lengths of extruded Tenite II, one inside the other, and then hot formed. Strong enough to support the weight of a man, it is deep enough to be easily grasped for an emergency jump. The extruded Tenite II rod with horizontal slot (center) is used by Douglas Aircraft Corp. as a fairlead in openings where a group of wires and pipes comes through bulkheads and is subject to chafing. Bent oversized and snapped into the perimeter of the hole through use of hot applications, the rod forms a smooth finished edge, the slot fitting tightly in place. Millions of identification tags (bottom) are needed by the Quartermaster Corp. The principal production problem was the synchronization of the stamping device to cut the holes and the tags from the hot Tenite ribbon as fast as it came from the extruder

10 When leather piston heads on tool lifts were found to require replacement every 90 days, the W-G Engineering Co. developed injection-molded Vinylite piston cups for which they now have patents pending. Unaffected by water, oils and most other liquids encountered in hydraulic systems and therefore giving accurate and permanent fit, these piston head cups promise to replace both leather and rubber on hydraulic lifts, automotive brake systems, door checks, and in fluid, gas and air pumps

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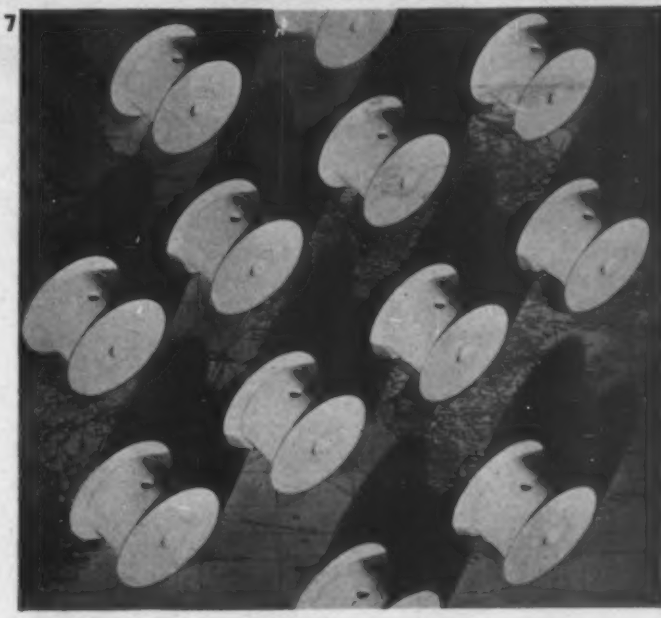

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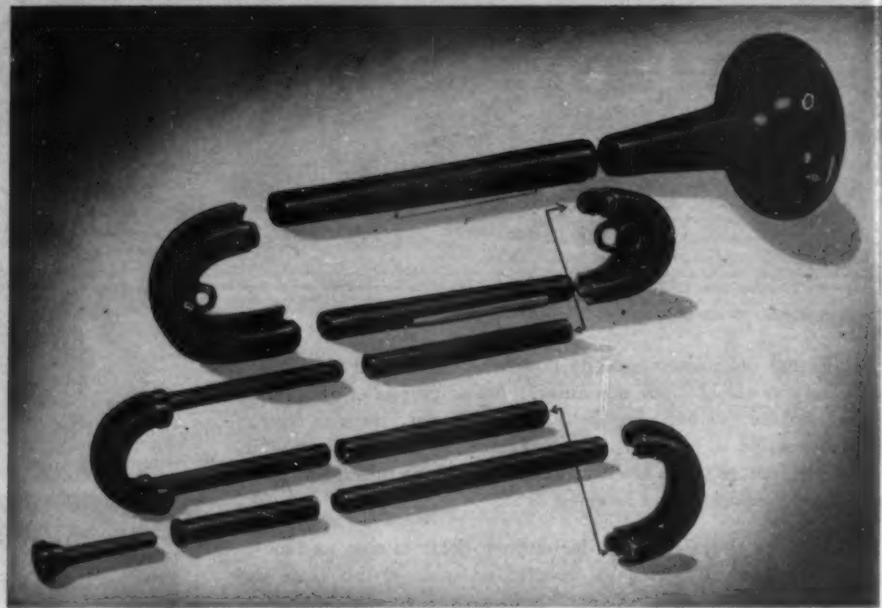
The new Army bugle



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SOME time ago, MODERN PLASTICS told how a musical instrument company and a plastics molder formed a team in order to put across the adoption of a plastic bugle by the U.S. Quartermaster Corps.[1] This was accomplished through the use of a model which, when played by the solo cornetist of the U. S. Army Band, blew sweeter, louder and more easily than its good old brass opponent. Since the fateful day when the QC Plastics Section gave the go-ahead signal, a great deal of blood, sweat, tears and work—and even occasionally a little profanity—has been reported from the Chicago area, where the two companies mentioned above are located.

A bugle is made up of slightly more than two full turns of conical-bore tube without lateral openings. Inasmuch as (to the best of our knowledge) no molder has been able to employ flexible cores in standard injection molds, it was, of course, necessary to divide the bugle up into a number of different parts before it could be molded. Until a very short time ago, it was thought that the bugle could be molded satisfactorily by using 13 separate parts. Assembly difficulties, however, could not be overcome, and it was necessary to change the design so that the number of parts now making up the bugle totals fifteen.

An explosion view of these parts is shown in Fig. 1. From the length of certain of the pieces it can be seen that some of the core pulls must of necessity be very long and, as a matter of fact, one of them has approximately an 8-in. stroke. This necessitated the designing of auxiliary core-pulling equipment to be attached to the mold. Two combination molds, each accommodating 7 different parts, and one single-cavity mold for the bell were constructed. Figures 4 and 5 indicate the complex construction of these molds and some of the Rube Goldberg arrangements which contributed to their operation.

After much testing, cellulose acetate butyrate had been chosen as the plastic from which the bugle was to be molded. The dimensional stability and low water absorption of the material, its toughness and its excellent surface luster, all make it suitable for this variety of application. Climate and weather conditions will not affect it—an important factor since the bugle accompanies our troops all over the world.

In order to meet the Army requirements that the bugle be suitable for a band instrument in addition to serving for bugle calls, a tuning slide running from G to F had to be provided.

[1] "Taps for brass," MODERN PLASTICS, 20, 62 (Nov. 1942).

This presented one of the major problems in the design, for the slide had to be thin in order not to have a step in the air chamber which would destroy the tonal quality. In other words, a musical instrument must be a streamlined instrument, on the inside at least. It was finally decided that this problem could not be overcome in the molding as the section would be too thin to fill out properly, so the slide part was purposely molded with a slightly heavier section than required. This, of course, resulted in an additional machining operation in order to reduce the wall section of the slide.

For this operation the molder designed a cutter for shaving the outside diameter of both tubes on this slide which made use of two rotating cutters through which the tubes were passed. The operation was accomplished by means of a jig and clamps which held the entire slide firmly in position while the tubes were passing through the cutters. Inasmuch as the slide had to be a perfect fit in the bore of the bugle, the tolerances on the shaving operation were necessarily very close. After the first experimental bugles had been produced, the carballoy tips used as the cutting agents were quickly replaced by diamonds. At last reports, the diamonds were standing up very well and were doing a perfect job.

In most cases, most of the assembly problems in plastic parts are carefully left in the hands of the molder, but in this instance the musical instrument company chose to assemble these 15 parts to produce a perfect musical instrument. It would be foolish to report that cartons of bugle components were shipped to the instrument company and that the assembly line immediately went into the production of bugles. The truth, as a matter of fact, is just the reverse. Brass craftsmen were attempting to handle a material entirely foreign to them, and it was therefore necessary to educate all of the workmen who were to come in contact with this assembly job. Various methods of gluing and welding were tried, the inferior ones immediately discarded, and those that worked out better given further careful study. An example of know-how gained is that all surfaces to be glued or welded are now bathed in carbon tetrachloride in order to remove the last vestige of grease or wax. This "trick" did a great deal toward guaranteeing welds which were 100 percent perfect. Inasmuch as the entire assembly operation of the bugle is one of welding joints, this knowledge played a large part in the successful use of plastics in the bugle. (*Please turn to page 142*)

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1—Explosion view of the 15 separate parts into which it was necessary to divide the bugle for satisfactory molding. 2—Complete set of parts from one of the 3 combination molds. 3—The 7 parts (above) were molded in one combination mold while bell (below) was molded in a single-cavity die. 4—Auxiliary core-pulling devices were designed as integral parts of both combination molds because of the length of the core pulls. 5—Here the combination mold for parts shown in Fig. 3 is mounted in the press

ALL PHOTOS, COURTESY ELMER E. MILLS CORP.

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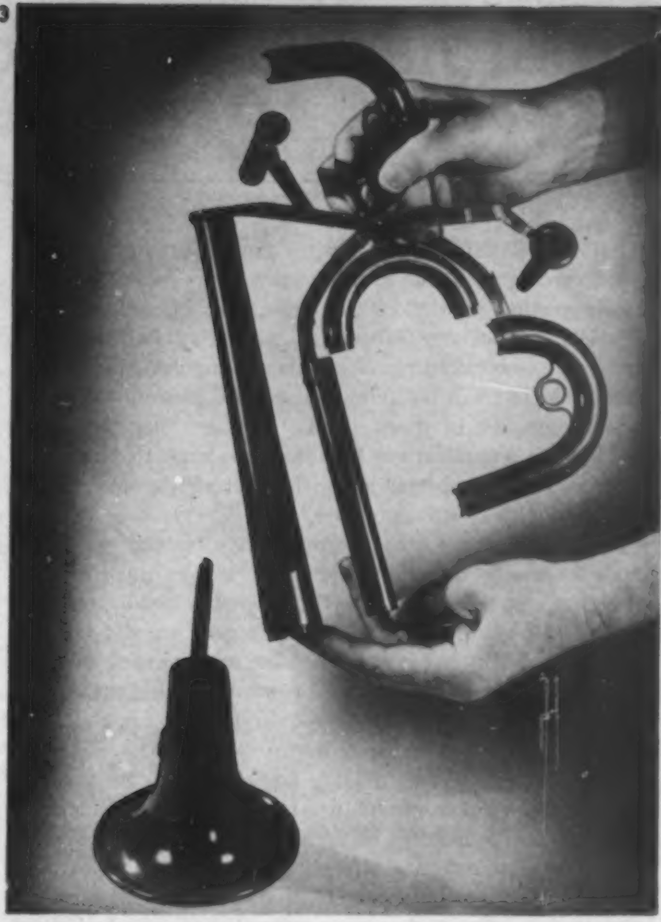

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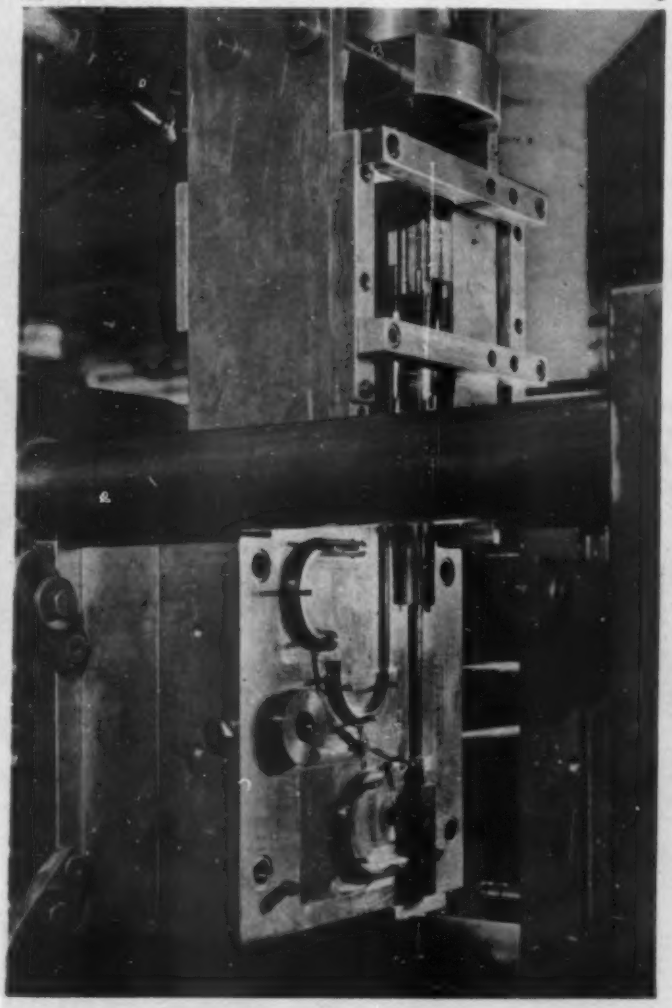

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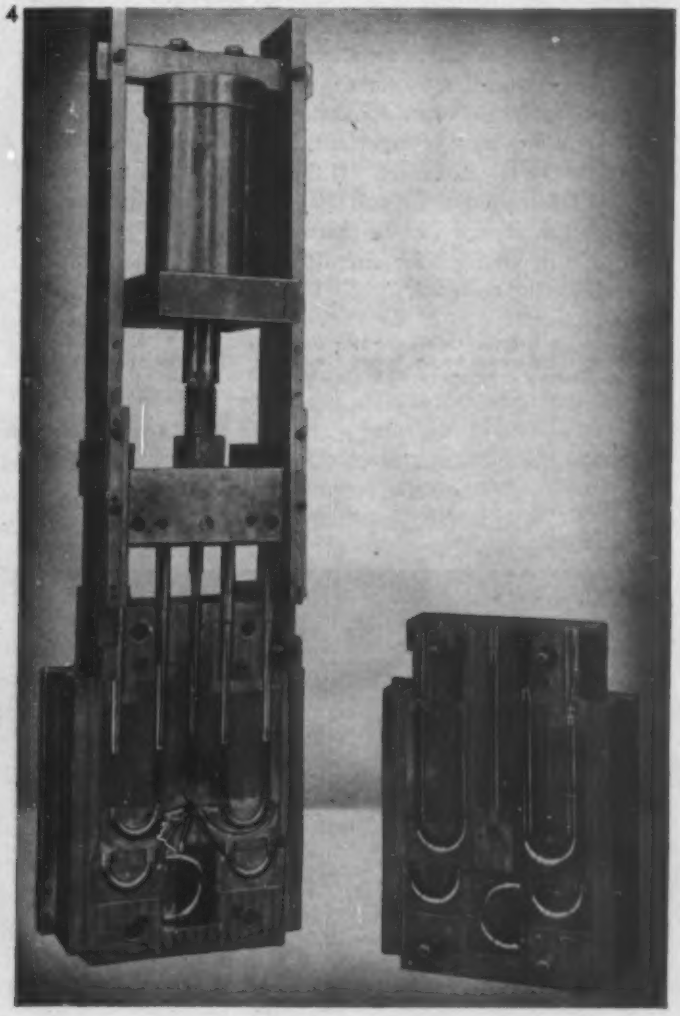


Fiberglas reinforced plastics

by TYLER STEWART ROGERS*

REINFORCED plastics and the properties of suitable reinforcing materials are attracting ever greater interest despite wartime restrictions that limit study of many of these materials, particularly Fiberglas. According to plastic research men, reinforced plastics are not being developed as replacement materials for aluminum and magnesium to relieve critical shortages in these metals. Rather, they are being used in certain applications because some laminated resinous materials can do a better job with lower weight and can be fabricated with fewer man-hours.[1]

These advantages are achieved partly by the resin and partly by the reinforcing material. The resin must be of a type that can be hardened with sufficiently small pressures so that costly dies and molding equipment are not needed. The resins which have contributed the most toward lowering man-hours and tooling costs, and toward speeding the output of reinforced plastics products, require pressures in the order of 0 to 80 p.s.i. and occasionally up to 100 p.s.i. If higher pressures are required, molding equipment becomes costly unless large volume production involving single shapes in sizes that can be handled on high-speed presses is achieved.

For the construction of aircraft and in similar applications, the ideal seems to be a combination of resins and reinforcing materials with which large or difficult shapes can be formed by wrapping a flexible reinforcement around a form, painting or impregnating it with a resin in liquid condition, and hardening the combination by some quick and simple process that does not require elaborate apparatus. While the part played by the reinforcement is important, it is no more so than that played by the selected resin. If the resin does not lend itself to rapid fabrication of difficult shapes with low man-hours of labor and minimum tooling there is little to be gained by increasing its strength for aircraft use through the addition of a reinforcing material.

* Technical director, Owens-Corning Fiberglas Corp.

[1] See report of speech by Dr. Irving Muskat at SPI Western Plastics Conference, MODERN PLASTICS *20*, 98 ff. (March 1943).

With a suitable resin, however, the most important physical property of high ratio of strength to weight depends upon the reinforcing material employed. While a number of reinforcements are being used today, including various papers, cotton and other organic fabrics, and glass fibers in the form of Fiberglas cloths, we are here concerned with the properties contributed by Fiberglas.

Before mentioning some of the published properties of Fiberglas reinforced plastics and giving more specific data on Fiberglas itself, it should be noted that this material, whatever its advantages or possible deficiencies, is now classed as a critical war material and is under allocation by the War Production Board Conservation Order M-282.[2]

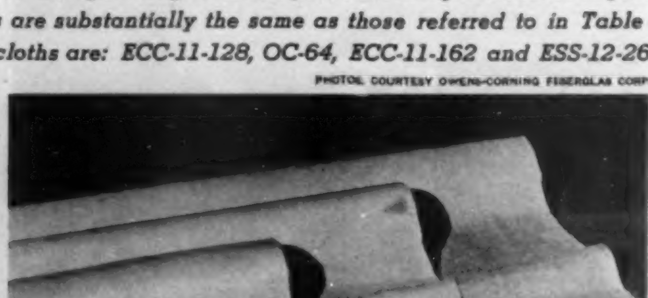
In view of the many other uses for Fiberglas fabrics that are deemed critical in the war effort, only a part of the total output is allocated for reinforcing and this condition is likely to continue throughout the war period. It has been established that some applications for which reinforced plastics are highly appropriate demand properties that so far have been found exclusively in combinations using glass fibers as the reinforcement. Efforts are being concentrated on certain specific applications of this character.

Published facts about Fiberglas reinforced plastics and laminates are summarized in Table I, which is drawn largely from data previously issued by the plastics manufacturers and published in MODERN PLASTICS and PLASTICS CATALOG. From these tables it will be observed that the more successful Fiberglas reinforced plastics show very high tensile strength, flexural strength, flexural moduli and good impact strength combined with low specific gravity and water absorption. That the tensile strengths shown in[2] the table have been exceeded is indicated by the statement of (*Please turn to page 140*)

[2] J. D. Lincoln in his address before the SPI Western Plastics Conference (MODERN PLASTICS *20*, 62.—June 1943), noted that while Fiberglas for reinforcing has been a main item with his company, he is compelled to turn to other reinforcing agents because his requirements alone, if they could be filled, would consume more Fiberglas cloth than is now available. While the production of Fiberglas textiles is being increased steadily, Mr. Lincoln said that the demand for reinforced plastics is so huge that no one material can ever capture the whole market for the reinforcing element.

1—In the background, left to right, are Fiberglas cloths ECC-11-128, ECC-11-162 and ESS-12-261 while in the right foreground is a piece of Fiberglas reinforced plastic. 2—These cloths are substantially the same as those referred to in Table I From right to left the cloths are: ECC-11-128, OC-64, ECC-11-162 and ESS-12-261

PHOTOS COURTESY OWENS-CORNING FIBERGLAS CORP.



High-frequency gluing of resins

by WALTER GODFREY* and PAUL H. BILHUBER†

SINCE the advent of metal as a structural medium, the use of wood has been restricted to secondary applications such as furniture, pianos, small homes and the like. However, the war has forced us to return to wood as a basic material for use in fields formerly dominated by metal. Airplanes, gliders, boats, truck bodies once more are being made of wood. Since the woodworking industry had not been compelled, like other industries, to place manufacturing on a mass production basis, it found itself many years behind in these production methods when brought into the competitive manufacture of production items. The metal industry had developed forgings, stampings, drawings, extensions, riveting and spotwelding. To compare with these developments, the wood industry in the past several years has adopted the use of synthetic resins as adhesives, molding processes to form compound sections rapidly and heat developed by high frequency radiation of electrical power to accelerate the process of wood fabrication.

This latter device, which has been used in production for about a year, has proved to be a remarkable weapon in the hands of the woodwork manufacturers. Due to the extensive use of the high-frequency machine, the rate of production of cargo-carrying glider parts manufactured by Steinway & Sons is increasing continuously with an ever decreasing cost to the Government. The first high-frequency machine of this type used by this company was intended for the gluing of grand piano rims of laminated construction. The unit, having an input rating of 15 kw., was delivered in January 1942, and successfully employed in experimental gluing of piano parts. When all piano manufacture ceased by order of WPB in May 1942, the machine was applied to similar work on aircraft parts. From then on it was but a matter of time before numerous jigs and fixtures were yielding several hundred percent of their originally computed output.

To date a great deal of literature has been published on high-frequency electrostatic heating. Unfortunately, much of this information is of a controversial nature. Different groups, although in agreement on the fact that the heating is basically caused by molecular friction within the material, offer differing explanations of the electrical phenomena involved. One school of thought claims that due to the frequency involved, standing waves appear along the electrodes with a resulting non-uniformity in heating. Other groups claim that one-half a standing wave exists between the electrodes and the other half between the electrode and the machine. Again this is supposed to result in non-uniform heating with a concentration of heat existing midway between electrodes. Finally another group, probably the largest, insists that any unusual heat concentration, usually at the center, is due to migration and concentration of moisture within the wood.

Despite the various claims and counter-claims, wood fabrication using synthetic resin glues has been immeasurably advanced by the use of this high-frequency heating. With particular reference to urea-formaldehyde glues that comply with Army Spec. A.N.-G-8, the results have been extremely favorable. Phenolic resins requiring higher setting temperatures are more sensitive and require closer control at these elevated temperatures.

Since wood, rubber or other non-conductors of electricity are used as insulation material at ordinary voltages and frequency, it is obvious that to induce correct flow through these materials, their effective resistance would have to be measurably reduced. An appreciable increase in frequency will allow for the use of reasonable voltages to bring about a resultant flow of current within these non-conductors. Although the result would appear to be similar to direct or alternating current resistance heating, ordinary resistance and current values cannot be used to calculate results. However, the amount of heat produced under a fixed set of conditions is computed on the basis of the physical rather than on that of the electrical properties of the material treated. The electrical characteristics of the material when in the press, such as its capacitance or possibly its power factor, are needed only to give an approximate indication as to the setting of the high-frequency unit. In some devices even this is not necessary. Once high-frequency electrostatic heating is understood, relatively few calculations need be made to determine the power and length of time required to perform any definite operation.

One of the basic advantages of high-frequency heating lies in its ability to heat the complete mass of material uniformly throughout. However, this statement must be qualified. As stated previously, it is possible under certain conditions to obtain non-uniform distribution of heat. These conditions should be avoided, therefore, by using the proper machine for the job, by correct designing of the electrodes, and by controlling the density and moisture content of the part being heated. To avoid the possibility of a standing wave along the length of the electrode, it is necessary merely to keep all the dimensions of the electrode small as compared with the wave length of the current flowing within it. As an example, a machine operating at a frequency of 2 megacycles

* Assistant Chief Engineer, Steinway & Sons.
† Vice-president in charge of research & development, Steinway & Sons.

ALL DRAWINGS, COURTESY STEINWAY & SONS

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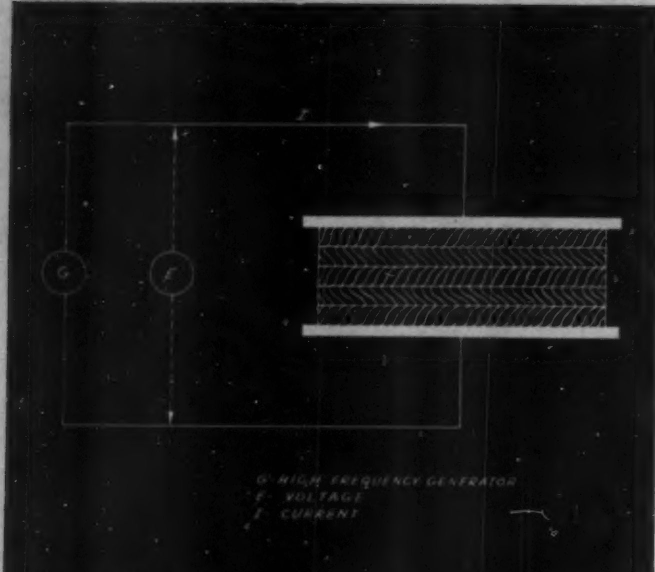

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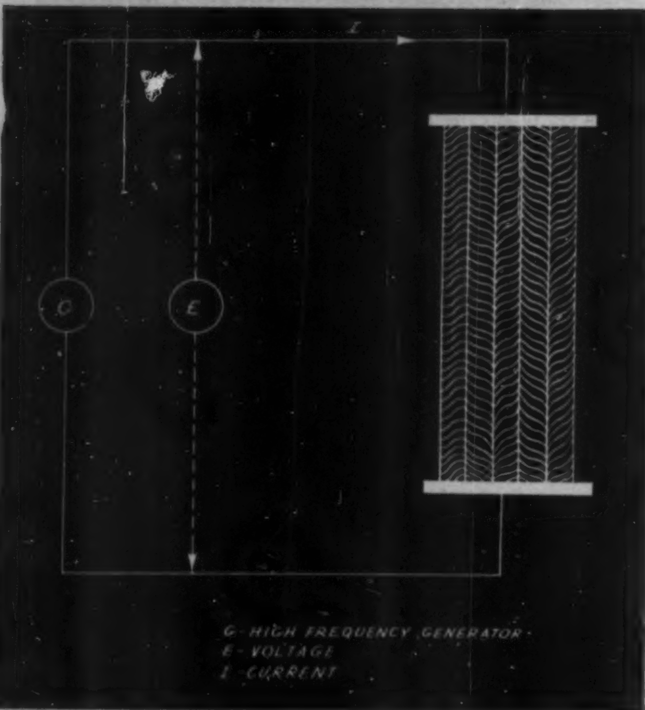

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of 150 meters wave length will allow for the use of electrodes approximately 25 ft. in length.

If the moisture content of the material can be kept uniform—that is, within 3 percent variation—the likelihood of hot spots appearing in the wood will be almost entirely eliminated. Also, it is quite advantageous to thermally insulate the electrodes if they are in the form of plates. This will keep conduction and convection losses to a minimum. If this is not done and temperatures above 212° F. are desired, a temperature gradient of as much as 25 percent could arise between the center of a block and its electrodes. When the temperatures are kept below 200° F. very little trouble is encountered due to non-uniformity of heating. Where secondary gluing operations are to be heated, it is essential that the design of electrodes insure uniform power dissipation at maximum efficiency. Much depends upon correct electrode design and application.

It must not be forgotten that we are dealing with radio waves which cannot be transmitted as would ordinary industrial electrical power. The location and arrangement of electrodes involve the ability of the machine to transmit the power throughout the system of electrodes and the likelihood of the work absorbing this power uniformly.

The three established methods of introducing heat into glue lines or a mass of materials are known as perpendicular, parallel and stray field heating. Perpendicular heating (Fig. 1) is referred to when the glue lines or planes are perpendicular to the electrostatic field and parallel to the electrodes. The gluing of veneers in the manufacture of plywood or the gluing of laminations to form curved sections such as wing bows, are considered as being treated by perpendicular heating. The preheating of plastic material before molding also is done by perpendicular heating.

Parallel heating (Fig. 2) requires the plane of the glue line to be parallel to the electrostatic field and perpendicular to the electrodes. This method is considerably more efficient, since the power will be absorbed almost entirely by the glue line rather than by the wood itself. Where wing spars are being made of several laminations that are a half-inch or more in thickness, the power required to set the glue in perpendicular heating would be beyond the range of the ordinary machine of 15 kw. or less. In such a case, the electrodes are located so that the glue lines alone are treated—e.g., by parallel heating—thus reducing enormously the power and time requirements.

The third form of heating, known as stray field heating (Fig. 3), is more complicated while offering the greatest possibilities. In this case advantage is taken of the fact that the electrostatic field, set up by 2 adjacent conductors or electrodes usually in the form of tubing or rod, does not travel on a straight line between these conductors. The field spreads out or widens as it leaves one electrode and finally converges as it reaches the other. Thus it is possible to reach glue lines and surfaces that are not directly in line with the electrodes but are a definite amount above or below them. Up to the present time no knowledge of the use of stray field heating in the woodworking field has come to our attention except that concerning its application by Steinway & Sons. Examples of these will be discussed later in this article.

High frequency does have disadvantages or, rather, certain shortcomings. These are not due to poor quality of work obtained. The disadvantages relate to the inability to overcome the electrical, chemical or physical condition that prevents the machine while in use from functioning as it should. High-frequency heating is not a cure-all. Where it is required

to heat very thin sections, a steam plate or electrical resistance grid usually is more desirable. High-frequency should be used in objects where the physical dimensions do not allow for normal uniform distribution of heat. Conventional methods definitely are not satisfactory where the depth of heat penetration is above $^3/_8$ or $^1/_2$ in. If an attempt is made to reduce the required heating time by increasing the platen temperature, the higher temperature of the wood at the platen as compared to that internally will cause prestressing of the entire block that is being treated. Case hardening, discoloration and glazing of the wood in contact with the platen are quite apt to result.

The high-frequency unit also has been put to experimental use as a flexible and effective substitute for a dry kiln. Whether wood is to be used in aircraft, pianos, furniture or trim, it always is dried before it is released for fabrication. Where a high grade of wood is required, as in superior grade furniture or piano soundboards and case parts, air drying periods of 1 to 2 years often are encountered. After this period of air drying, it still is necessary to kiln-dry the lumber before it is acceptable for fabrication. Since the turnover of material and space is slow, large inventories and much storage capacity are tied up for long periods, result ng in high operation costs. In addition, when one considers that after the lumber has been kiln-dried, there is as high as a 60 percent waste factor, it is readily seen that standard processes often involve unnecessary expenditures on waste wood. With the proper use of high-frequency heating, it has been possible to take green lumber and, depending upon its weight and thickness, reduce its moisture content to approximately 15 percent in a matter of hours and continue the drying process further to the required kiln dried stage.

In treating lumber in this fashion—placing the lumber after it is cut to approximate size between electrodes which are preferably in the form of large metal plates—we take advantage of a peculiarity of high-frequency heating. As previously mentioned, moisture concentrations result in hot spots which tend to evaporate the moisture more quickly. Coupled with the tendency of the exterior surfaces to run colder due to rapid dissipation of heat to the metal electrodes, this fact results in the block heating and drying from the inside out. This loss of moisture by the wood from the inner fibers outward eliminates any danger of case hardening, honeycombing or brashness. Checks and splits due to excess drying of the exterior also are eliminated. Extraneous and volatile matter such as water, tars and resins are removed with a minimum of discoloration to the wood surface.

However, the most important use of the high frequency machine is to speed up wood fabrication production. This is done by decreasing the time required to cure a glue joint—

ALL PHOTOS, COURTESY STEINWAY & SONS

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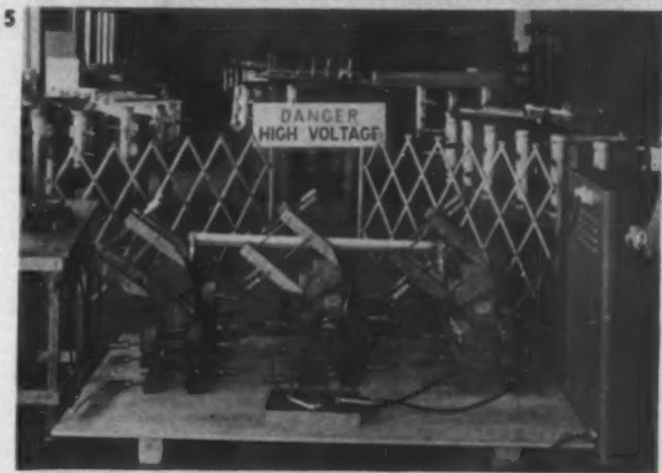

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1—This is a schematic view of perpendicular heating. 2—A schematic view of parallel heating. 3—Another schematic view, this one showing stray field heating. 4—A wing bow tip in an open press with press cawls and a copper sheet electrode visible on the floor. 5—Old style wooden hand clamps, wood frames and high frequency are being used to glue 3 pilot seat backs connected in parallel to a 1 kw. machine. Curing time is 4 min. compared to the 4 hours previously required. 6—Here wing ribs are being glued in multiples of 4 using the sandwich method. 7—A finished 3-man air-borne trooper seat rests on the floor. On the table, all joints of a similar seat are being glued by stray field heating

from 4 to 6 hr. to a matter of seconds or minutes. Army and Navy specifications require the use of urea or phenolic resinous glues. The urea glues while under pressure will set at a room temperature of 70° in a minimum of 4 hours. Most phenolic glues require heat to polymerize completely. In the use of the urea glues, it has been found that by raising the temperature to 170° F. the time required to create an effective glue joint can be reduced to 2 minutes. Increasing the temperature decreases the time with the result that glue joints have been cured in a few seconds. It is necessary therefore to insure that all parts of a glue joint or glue joints are elevated to at least 170° F. It is quite possible that some parts may get considerably hotter than others. This will have no effect upon the glue so long as the temperature remains below 350° F. This factor is quite important and allows for the extensive use of high frequency in complicated wood construction.

Fortunately, phenolic resins are restricted at the present time to use in the gluing of flat veneers to form plywood or in the impregnation of plywood as it is being used by the molding industry. These 2 uses insure relatively uniform sections and, in consequence, uniform heating. This, of course, is extremely important since a temperature of 240° F. requires an application of heat for 20 minutes. If it were desired to insure a minimum temperature of at least 240° F. throughout non-uniform sections, some parts could easily reach the point where they would scorch or possibly ignite. Temperatures above 300° F. are more difficult to control and therefore are avoided where possible. However, all glues on the market today will set at temperatures considerably below 300° F.

A glider wing bow, $1^1/_{16}$ in. x 13 in. x $16^3/_4$ ft., formerly requiring a curing time of 4 hr. under pressure, was the first aircraft part to be treated. A urea-formaldehyde glue was used as a bond between the eight $^1/_8$-in. laminations. When the press was adapted to high frequency heating the pressing time was reduced to $8^1/_2$ min. and the amount of springback in the bow was reduced by 75 percent as compared to cold setting in the press. Figure 4 shows the press and the tie-in to the 15-kw. high frequency unit. The output of the high frequency machine was assumed to be 50 percent of the power put into the tubes. In this case, the output would be about 6 kw. The weight of the bow strip was approximately 57 pounds. It was decided to raise the temperature of the glue lines to 170°, this temperature requiring a curing time of only 2 minutes. As the temperature of the glue line is being raised, the curing time is accelerated so that the part need not be kept at 170° for more than a minute. The following calculations then were made:

Assuming the coefficient of specific heat of the wood to be .45, the Btu required to raise the temperature from 70° F. (room temperature) to 170° F. would be:

$$\text{Btu required} = 57 \times .45 \times (170\text{–}70) = 2565 \text{ Btu.}$$

The 6-kw. output available would give us

$$6 \times \frac{3413}{60} = 341.3 \text{ Btu/min.}$$

Assuming 10 percent heating loss in the press, we have

$$\frac{2565 \times 1.10}{341.3} = 8.3 \text{ min. required.}$$

In addition, 10 min. were permitted for the part to cool sufficiently to assure the retention of the bow contour.

These calculations were checked by inserting thermocouple leads into the center of the bow at various points. At frequent intervals, the machine was turned off and the pyrometer connected to the thermocouple wires with clip-on leads. The actual readings were not far off the calculated figures. A third check, which is reliable when an experienced hand is available, is observation of the state of the glue beads forced out at the glue lines. The output of this jig thus was increased several hundred percent, removing the need for additional presses as production demands were stepped up.

Recommended practice calls for the electrodes to overlap the edges of the wood by an amount equal to the distance between them. In this case, the electrodes should have had an inch overlap on all 4 edges. Due to the construction of the press which had been designed for cold setting of the glue, it was found necessary to eliminate the one-inch gap on the

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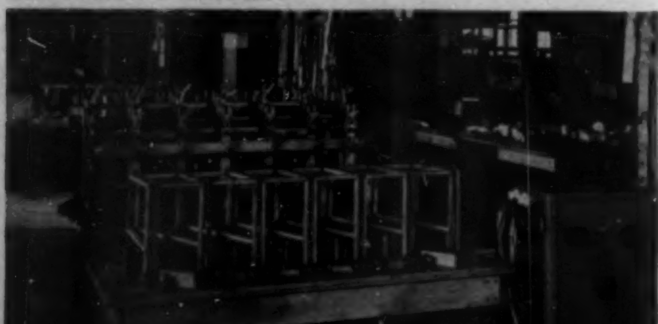

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8—Empty 3-man seat jig shows built-in electrodes. 9—At right, ramp used for unloading jeeps from planes being glued by high frequency. Finished ramp at left. 10—All glue joints of sanitary container are heated by stray field heating at same time. Finished container, right

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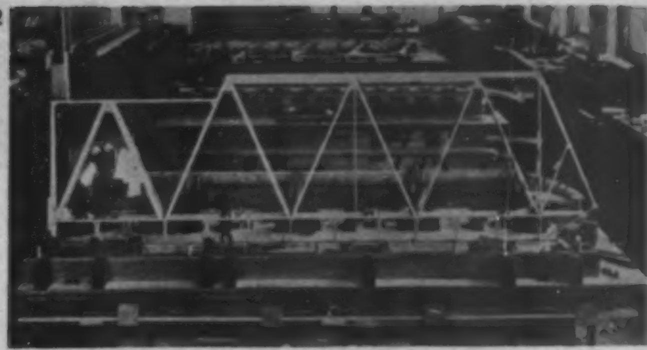

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11—High frequency "gun" used to iron and spot-glue assemblies—here a nose fairing skin. **12**—*All 27 ioints of this elevator were glued at the same time. In background is pneumatic hose used for pressure.* **13**—*Wing bow tip with cawls in pressure position; safety gates in place*

lower edge. By using a mechanical spreader to insure uniform glue spread and even moisture distribution, distortion in the laminated bow due to non-uniform curing was prevented. Whenever the glue forced out between laminations tended to form pools and contact both electrodes, it was removed by swabbing with cotton waste. The use of a mechanical spreader, however, will permit close enough control of the thickness of the glue to reduce any danger of flash-over. As all work has a certain amount of excess material to allow for finishing, any charring of the glue along an edge will not go deep enough to necessitate rejection of the finished piece.

By properly locating the presses, one high frequency machine can be kept in continuous operation.* It was found that by keeping the size of the presses within 50 percent of each other, it was not necessary to change the setting of the tuning coils on the output circuit of the 15-kw. machine. As mentioned earlier, a knowledge of the electrical capacitance of the wood within the electrodes is all that is required to set the machine. Current designs for machines of medium size—10 to 20 kw.—require the load (wood between the electrodes in the press) to be tuned to the output circuit of the machine. Since the electrical capacitance of wood is a direct function of the width multiplied by the length divided by the thickness, this ratio should be kept as constant as possible. In this way, tuning changes will be kept to a minimum and handling time between presses will be speeded. The responsibility of the operator in caring for the machine also is lessened.

A press involving a single or compound curve in wood more than $^1/_8$ in. thick cannot ordinarily be used to turn out more than one thickness. This is due to the difference in the radii of curvature of the 2 pieces. This means that only 2 electrodes, one on either side of the wood, are used. However, to keep the heat that is produced concentrated in the work itself, it is desirable to use, wherever possible, the 3-electrode method whereby 3 electrodes are used between and on the outer surfaces of 2 similar loads. The 2 outer electrodes are interconnected to form one electrode. The outer electrodes are connected to the ground side of the machine, and the center electrode to the high voltage side. This hook-up will tend to keep the press at the same potential as the electrodes and also have a tendency to keep to a minimum the heat generated in the press itself.

If the press is non-metallic as is usually the case in compound and curved sections, the electrodes can be sprayed directly on the mold with a Shoup process gun, or a thin preformed sheet of metal can be used between the press and the wood. It has been found that by inserting a non-conductor between the metal electrode and the wood, the excess glue squeezed from the glue lines will not be allowed to come in contact with the metal. The tendency for flash-over then is materially reduced although not entirely eliminated.

Smaller items, usually required in greater numbers, can be treated in essentially the same manner. Where curved sections such as pilot seat backs, wing ribs and bulkheads are needed in quantity, it is found desirable to make several identical presses and interconnect them with the machine. As long as the load is balanced, heating will be uniform. The time required to bring the temperature to the necessary level will be based on the weight of all the pieces being cured.

A set-up is shown in Fig. 5 wherein several seat backs are to be treated at the same time. As has been pointed out, the amount of power put into a material between electrodes is a function of the dielectric of the material, the frequency and the voltage applied across the electrodes. It is possible that the work between electrodes is too thin and will flash over if too high a voltage is impressed upon it. If the time desired to cure the glue is increased excessively by subsequent lowering of the applied voltage, it would not be efficient to interconnect the presses as described. In such a case, the press should be designed on the 3-electrode principle with the parts located one above the other as shown in Fig. 6. The voltage impressed across the load then can be greatly increased. Although the overall curing time may increase slightly, the number of parts cured in a given interval will be much higher.

Plywood, wing ribs and all thin fabricated sections can be formed in multiple units. The most common cause for flash-over and burns, aside from excess glue, is the presence of metallic parts. These metallic parts may appear in the form of fittings to be molded with the wood, plate nuts attached in a previous operation (*Please turn to page 154*)

Booster coil housing

ALL PHOTOS, COURTESY ECLIPSE AVIATION DIV., BENDIX AVIATION CORP.

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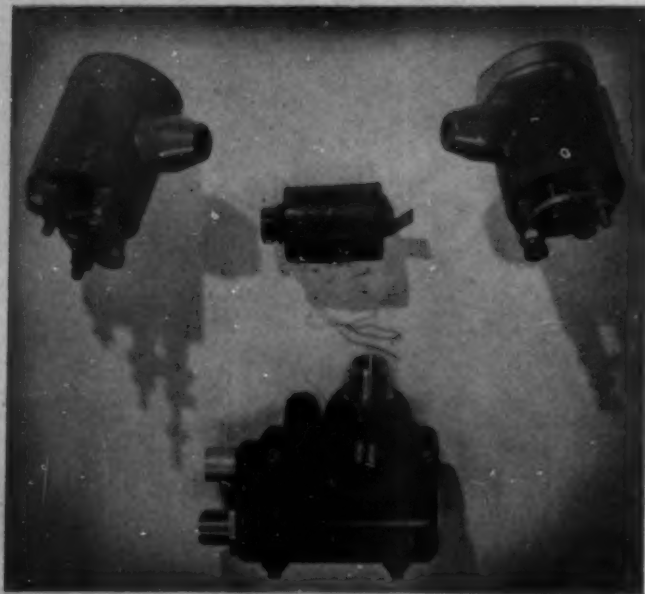

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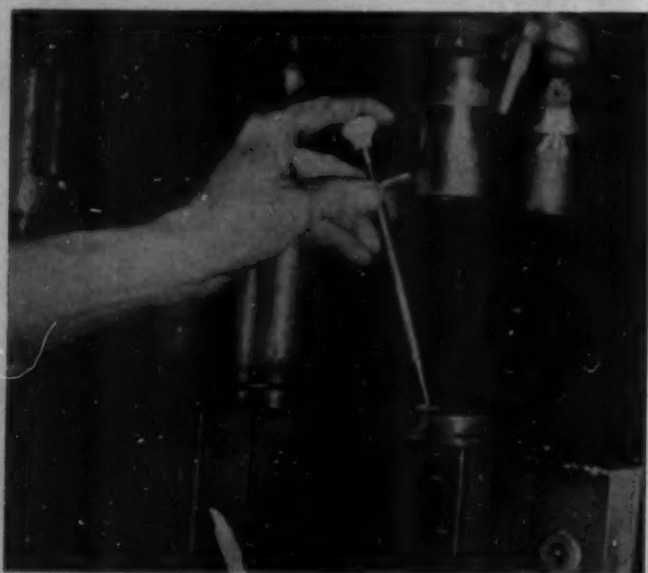

BACK in the days of Henry Ford's Model T, four separate spark coils were used as standard ignition equipment, and those who drove that remarkable model will remember the rectangular box stowed under the dashboard to hold the coils. Customary procedure, whenever the motor missed, was to give the box a well-aimed kick! This same spark coil ignition was responsible for a great many broken arms due to faulty timing or failure to retard the spark before doing a job of cranking.

As motor science advanced, the Model T acquired a magneto which was used in conjunction with the spark coil ignition. This still did not do away with "playing the piano," however, or obviate the necessity of adjusting the vibrator gap so that Lizzie would hit on all four. It merely gave added power to the motor at high speed. Then the self-starter became standard equipment and, as this unit turned the motor at a high speed compared to cranking, it was possible to do away with the coil completely, and not only to run but also to start the motor on the magneto.

This worked very well as long as all the high-tension wires were dry, spark plug porcelains clean, and the weather balmy However, when the oil in the crank case became stiff because of low temperatures, or shorts developed in the wiring system due to moisture, Lizzie got balky. Excess use of the starter would run down the battery, and the old standby crank would have to be resorted to. Certain strong and dexterous individuals were able to spin the motor at a high rate of speed and thus get it started, but the majority were either not strong enough or did not want to put their arms in jeopardy. Consequently they either left Lizzie where she was or tried another alternative. This alternative was jacking up one of the hind wheels so that when the car was put in gear the hind wheel would act as a second fly-wheel, thereby making it much easier to get the motor spinning at high speed. All this hocus-pocus developed, apparently, because science had advanced from the spark coil age to the magneto age.

It would seem that our younger generation had no very close acquaintance with the Model T, especially that section of it connected with designing and developing airplane engines and their equipment, for the same mistake apparently

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was made again. Once again science advanced too far and we had a repetition of the peculiar situation of Model T days.

In cold or damp weather, the best of airplane engines are practically impossible to start with their standard magneto equipment. If they had to depend on magnetos alone, from the steamy jungles of Guadalcanal to the frigid shores of Dutch Harbor, the Air Corps ground crews would have trouble in getting instant starting—and hard starting has no place in either defensive or offensive aerial warfare. But thanks to what could be called a "backward advance," the engines in American aircraft start at the drop of a hat. An improved Navy model of Lizzie's first spark coil does the trick.

This unit is known as a booster coil for, as its name indicates, it boosts the voltage of ignition equipment so that a fat, red-hot spark is delivered across the points of each plug no matter what the temperature and with only a minimum of loss due to dampness. This simple device, small enough to be carried in a pocket, is the reason that airplane engines can start in a flash and get United Nations planes into the air with incredible speed.

One of the most important parts of this unit is the coil housing, 2 views of which are shown in Figs. 3 and 4. Due to the high voltage being handled, it was necessary to use a material of very high dielectric strength. A mica-filled phenol-formaldehyde was therefore specified. Four brass inserts molded into the bottom of the piece serve as low-voltage primary connections as well as mounting elements for the vibrator, the assembly of which is clearly seen at the left and right in Fig. 1. A fifth insert is molded into a large round boss which protrudes from the side of the unit. This serves as a high-tension connection between the secondary winding of the booster and the distributor of the motor. It is this part, protruding from the side of the unit, which changed the piece from a fairly simple molding job to one of great complexity, especially as low-loss material had to be used.

The difficulties of molding mica-filled materials led to a series of molding headaches: insert pins bent, light pieces were produced, porous sections and egg-shaped holes abounded. All these problems, however, were overcome in a single-cavity experimental die before the two 4-cavity production molds were built.

The first tool design incorporated 5 knockout pins for each part, 4 of the knockouts being the insert pins and the fifth pin knocking out against the slide or removable mold section which formed the projecting round boss on the side. The complete cycle was as follows: the inserts were loaded into the cavity by means of an ingenious tool shown in Fig. 2. This tool, acting as a sort of plunger, held the inserts securely until they were in place on the pins, after which they were released by pressing the knob as shown in the illustration.

A carefully weighed quantity of the material in powder form then was loaded, the mold closed at low pressure and allowed to remain in this position for approximately 15 seconds. The high pressure then was very gradually turned on—so gradually, in fact, that it took about 40 sec. to completely close the mold. The mold, which was opened after a 5-min. cure and a 3-min. chill, was so designed that the part remained in the cavities. The molded part along with the loose mold section then was knocked out by the 5 knockout pins mentioned previously. The loose (*Please turn to page 144*)

***1**—The 4 brass inserts molded into the bottom of the booster coil housing serve as low-voltage primary connections as well as mounting elements for the vibrator shown assembled here at the left and right. **2**—Inserts are loaded into the cavity by means of this tool which holds the inserts securely until they are in place on the pins, then releases them when its knob is pressed. **3** and **4**—Two views of the mica-filled phenol-formaldehyde housing showing 4 brass inserts molded into the bottom and a fifth insert molded into a large boss which protrudes from the side. **5**—Here a loose mold section still is attached to a molded housing. **6**—The molded housing has been pushed part way back on the force plug while the loose mold section is removed. **7**—A blueprint of the booster coil housing*

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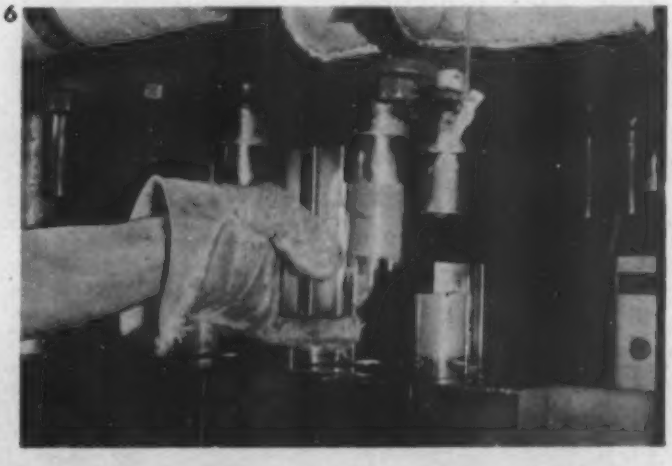

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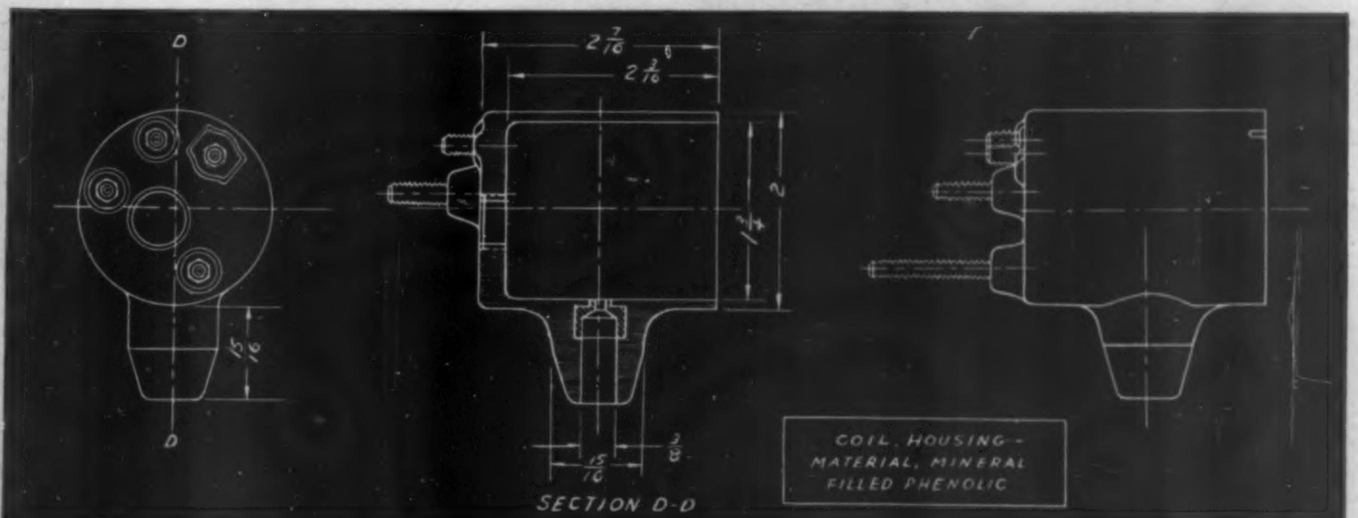


Life ON THE PLASTICS NEWSFRONT

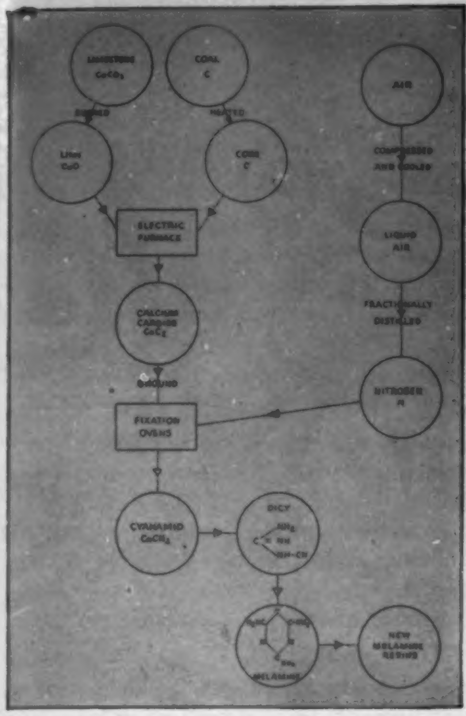
(*Above*) **PRODUCTION OF AMERICA'S LEADING COMBAT PLANES** is being speeded by increasing use of plastic parts.

(*Above*) **NERVE CENTER** [redacted]

(*Above*) **SPLIT-SECOND TIMING** is provided by this magneto. Distributor heads are of MELMAC* for dielectric strength, heat and arc resistance.

MELMAC DISTRIBUTORS SERVE ON LEADING PLANE ENGINES

Many of today's combat planes are giving better performance due to increasing use of plastic parts. One of the outstanding developments is the use of MELMAC in ignition systems for both the radial and "in-line" type aircraft power plants. Typical is the ignition system made by Scintilla Division of Bendix Aviation Corporation. Because of its high dielectric strength (430 Volts/Mil.), high arc resistance (130 sec. ASTM average), and high heat resistance (300°F.), distributor heads on Scintilla-built ignition systems are molded of MELMAC 592. A melamine-formaldehyde thermo-setting plastic developed by American Cyanamid, this mineral-filled material can withstand virtually any condition of service from the extremes of high altitude cold to torrid tropic heat. Other typical applications for MELMAC 592 include circuit breakers, terminal blocks, shields, relays, controls, switch plates and instrument panels. Many other uses are being found for this plastic and it is continually being adapted or modified to meet new and specialized requirements. Perhaps MELMAC 592—or another of the new thermo-setting molding materials developed by Cyanamid's research—can help *you* in meeting today's needs. Further information and data sheets will be sent on request.

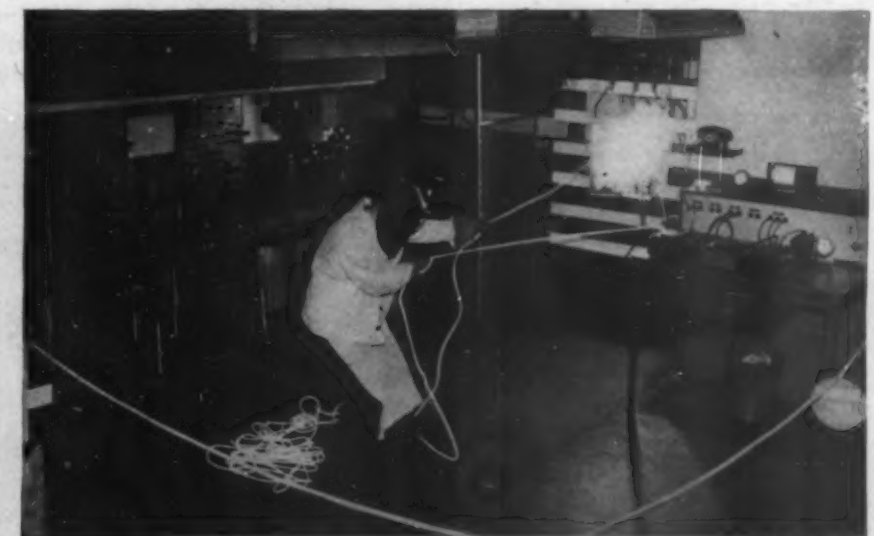


(*Above*) **FROM COAL AND AIR** is produced the organic nitrogen compound melamine, source of MELMAC plastics and many important resins. Until recently a chemical rarity, Cyanamid pioneered in the commercial development and production of this material.

(*Above*) **THE LUNCH WHISTLE BLOWS** and this war worker picks up his vacuum bottle, an indispensable part of every lunch kit. Leading manufacturers of these bottles, such as the American Thermos Bottle Company, and Landers, Frary & Clark, use tops molded of BEETLE — one of many important wartime applications for this Cyanamid plastic.

(*Below*) **BUTTONS FOR THE SOVIET ARMY** and other Allied fighting units are being molded out of BEETLE*. Also serving all branches of America's own armed forces, these buttons are outstanding because of uniformity, smart appearance and resistance to repeated launderings. A Grade Two BEETLE is available in black and brown in one standard plasticity in a reduced price range to meet increased demands.

(*Below*) **INTENTIONAL OVERLOADING** of a service-type electric switch causes an "exploding" arc in a test to determine how much current it can withstand. Equally severe tests of MELMAC's dielectric strength, arc resistance and heat resistance have proven the superiority of this plastic for many electrical uses.



*Reg. U. S. Pat. Off

AMERICAN CYANAMID COMPANY

PLASTICS DIVISION

30 ROCKEFELLER PLAZA, NEW YORK, N. Y.

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Chromium plating molds

by ARTHUR W. LOGOZZO*

DESPITE the fact that most plastics manufacturers have been familiar for many years with the chromium plating of molds, their acceptance of the idea has been slow and this slowness has been justified. On the one hand there has been a lack of unity between the plastics molder and the plater; on the other, a low quality of plating attributable to poor technique in the hard chromium shop. This paper is written for the express purpose of dispelling the misunderstanding existing between molder and plater, and of explaining certain techniques necessary for successful plating operations.

Advantages of plating molds

A properly plated mold has many distinct advantages over one that is unplated, irrespective of the high-grade alloy steels used. A harder surface, less sticking, elimination of pitting caused by gases of reaction, reduction in breaking-in time, higher finish of molded part, better flow, all combine to make chromium plating of molds worthwhile. When plated, these expensive tools no longer need repolishing and thus much production time is saved. This one factor would in itself warrant the additional expenditure.

Toolroom technique must change

The successful application of chromium plating of plastic molds must start with a change in toolroom technique. In the past a halfhearted polishing operation was performed on a mold well blackened by the hardening process. This resulted in hanging of material in corners. A completely polished mold is a prerequisite of chromium plating. Paradoxically, this can be handled more economically by pickling the hardening scale. In this way the base for a good polishing operation is prepared in less time than formerly it took for an inferior polish.

The pickling operation, performed after hardening and oil quenching, is as follows:

1. Anodic treatment at 6 volts in Anodex metal cleaner (8 oz./gal.) for 10 min. at 180° F.
2. Water rinse.
3. Immersion in muriatic pickle, 30 to 40 percent acid by volume (containing acid addition agent) for 10 min. (room temperature).
4. Rinse and a light brush with pumice if real clean surface is desired, then drying.

The usual draw operation can follow the pickling medium, after which the parts are ready for final grinding and polishing, etc. With a clean surface provided for the polishing bench, a much superior finish is obtained in a shorter time.

The polishing routine can be as follows:

1. Stone with No. 37320K stone as much as is necessary, depending upon type of machining.
2. Hand work or machine lap using No. 240 aloxite emery cloth. For real fine finish, follow with No. 320 aloxite.
3. Buff with emery cake and felt wheels, bobs or cones.
4. Finish buff with muslin buffs and fine steel rouge.

Kerosene is used in conjunction with all of the above sequences except the final finish, which (*Please turn to page 146*)

* Superintendent, Hartford Chrome Corp.

***1**—Chrome plating was used to give the necessary high finish on this force plug for the top half of a vacuum coffee maker. **2**—Arranging the anodes in "octopus" form not only permits great flexibility of use but eliminates the long-drawn-out process of making a complicated anode for each job*

1

PHOTOS, COURTESY HARTFORD CHROME CORP.

2

Aircraft design considerations*

by HASKELL R. GORDON†

WITH the development of new low-density high-strength plastics by the plastics industry, an effort is being made by aircraft designers to utilize the advantages of these materials in preparing new structural designs. It is generally agreed among airplane designers and manufacturers, and Army, Navy and Civil aeronautical agencies that the development of plastic or semi-plastic structural parts for aircraft will be promoted, encouraged and accepted only if the resulting structure shows promise of introducing advantages and superiority over conventional structures from a strength, weight, aerodynamic and ease of manufacture viewpoint, either simultaneously or separately. The following study has been prepared in an attempt to arrive at a preliminary evaluation of possible advantages of plastics in these respects.

PART I

The study of high-strength plastics as structural material for use in aircraft stressed parts of semi- and primary-structural nature is prompted in the main by the following reasons, in the order of their importance:

a. The urgent need to reduce overall weight in Army and Navy combat-type aircraft in order to arrive at better service performance, such as rate of climb and maneuverability as well as increased payload for a given gross weight. All types of new materials showing promising strength-weight ratios are being considered as possible superior replacements for present materials.

b. The need to increase the local stiffness of all thin gage sections on all airfoil shapes as well as on the fuselage without increase in weight in order to reduce presently encountered local structural failures arising from vibration, buffeting and flutter difficulties. Plastics are inherently low-density materials and therefore are potentially suitable for monocoque construction. Also, the damping characteristics appear to be more satisfactory than those of metals.

c. The need to increase overall cleanliness of all combat aircraft in order to attain increased speed characteristics. The inherently smooth surface and contours of molded plastics offer the prospect of greater aerodynamic cleanliness, and the possibility of stiffer and more stable skin offers the prospect of maintaining this cleanliness of both surface and geometric shape under air loads.

d. The need to reduce the number of man-hours required to manufacture aircraft assemblies. Molded plastic construction offers the possibility of combining what are now several sub-assemblies into one unit.

* Paper presented at the ANC-Industry Conference, sponsored by the Army-Navy-Civil Technical Subcommittee on Plastics, held in Philadelphia on Feb. 9, 1943.

†Aeronautical engineer in charge of Experimental Structures Unit Naval Air Experimental Station.

The use of plastic materials to overcome the above difficulties presupposes that an intelligent study must be made of the plastics as an engineering material, much the same as has been done with aluminum alloy and wood, and as is presently being done with magnesium alloy. No attempt is being made to consider the use of plastics or new materials in place of conventional materials such as aluminum alloy merely for purposes of conservation. Instead, the design with plastics is intended to arrive at an intelligently designed structure whose strength and stiffness characteristics are superior to those of conventional structures and will thereby achieve a satisfactory solution to the problems posed above under subparagraphs (a) and (b). It is assumed that in satisfying conditions (c) and (d) the plastic is at no disadvantage in strength and weight compared with the metal part.

In addition to the usual determination of the physical properties, sufficient basic theoretical analysis must be made with the plastics, evolving a comprehensive set of design criteria which will direct the trend of and check the results of tests of structural elements representative of the final structure, and eventually arrive at what are commonly termed as "design allowables" suitable for use in the design of any airplane. Throughout, it is to be emphasized that in order to take maximum advantage of the plastics or new materials, the design must be peculiar to the material intended for use—that is, the substitution of one material for another of entirely different physical properties can only be accomplished efficiently by proper redesign or redisposal of all masses consistent with all the best properties of the new material.

The first and most important problem to be solved with the use of plastics is that of weight. Combat aircraft have grown in weight tremendously in the past few years, to the extent that the original offensive purpose intended for pursuit, intercepter and fighter type aircraft has been overshadowed by the policy of the introduction of equipment and additional structure suitable for defensive qualities only. The net result has been the marked sacrificing of certain performance characteristics that are functions of low-weight aircraft only, such as rate of climb and overall maneuverability in flight. This offers a severe handicap to aircraft that must climb rapidly to engage enemy aircraft and thereafter execute rapid maneuvers to either move out of position and range of enemy gunfire or move into a favorable position to fire on enemy aircraft in a fraction of a second. It is agreed that a major portion of the so-called overweight is derived from such items as equipment and armor protection. Actually, the structural weight of an airplane is rarely greater than 25 to 30 percent of the gross weight. This then places a limitation to some extent on the points of greatest interest in considering substitutions that offer the greatest weight saving. However, it

must be emphasized that the most efficient use of new materials in any load-carrying capacity whether on fixed equipment or primary structure can only be made after an intelligent study of the structural design qualifications based upon analytical and laboratory test results treating the material in its basic element form, similar to the proportions intended for use in the final structure.

The second problem confronting the present-day airplane designer is one of lack of overall stiffness and rigidity prevailing in thin gage sections of metallic aircraft. The condition arises, almost always, wherein the designer must utilize a relatively high-density material and design around thin gages with local reinforcements in the form of longitudinal and lateral stiffeners arriving at a semi-monocoque structure. The use of thin gages to keep overall weight down results in a structure that has been designed to fail eventually in elastic instability or buckling rather than at ultimate developed material strengths. In so doing, the designer has first invited the development of numerous incomplete tension field and compression type wrinkles in the skin at relatively low applied flight loads, tending to disturb the pressure distribution sufficiently to cause an unpredicted redistribution of applied moments which in themselves may be sufficient to fail the structure. Secondly the reduced local moments of inertia prevalent in thin sections together with low values of internal damping capacity in metallic structures make it an easy prey to failure by vibration, whether engine excited or aerodynamically excited. These problems have taken on even greater importance when flying at high speeds in regions of aerodynamic compressibility near Mach Nos. ranging from .70 to .95, where vibratory, buffeting, and flutter conditions occur more frequently. The advantage to be gained in these respects with the use of a low-density material of relatively high strength is somewhat obvious since thin gage sections are no longer necessary and trends can be made toward designing full monocoque structures on an equivalent weight basis.

The use of plastics to arrive at a cleaner (aerodynamically) structure presents an interesting prospect in obtaining increased speed, climb and maneuverability. Also there is a prospect of increasing the production of airplanes by reducing the number of man-hours spent on construction. Apparently, it is necessary to use molded construction to realize such gains.

TABLE I.—MATERIAL PROPERTIES USED FOR STRUCTURAL EFFICIENCY ANALYSIS

Material	*Specific gravity*	*Flexural Strength, (modulus of rupture) p.s.i.*	*Flexural modulus of elasticity p.s.i.*	*Ult. shear strength, ∥ grain p.s.i.*	*Ult. shear strength, ⊥ grain p.s.i.*
x4130 steel	7.85	125,000	29,000,000	75,000	75,000
(18-8) stainless	7.85	185,000	28,000,000	125,000	125,000
Hickory	.79	19,300	1,860,000	1,440	....
Mg alloy (J-1h)	1.8	45,000	6,500,000	21,000	21,000
Al alloy (24S-T)	2.8	65,000	10,300,000	39,000	39,000
Paper-base plastic	1.41	33,900	2,200,000	15,300	14,800
Glass-base plastic	1.08	52,700	2,640,000	16,120	13,900

TABLE II.—WEIGHT SAVINGS* FOR FLAT SHEET IN SHEAR AND FLEXURE COMPARED TO ALUMINUM ALLOY 24 S-T

Material →	*Paper* %	*Glass* %	*Mg alloy J-1h* %	*Stainless steel 18–8* %	*X4130 steel* %	*Hickory* %
Flexure (1)	+30.3	+33.4	+22.8	−66.2	−102.0	+ 48.3
Flexure (2)	+ 3.5	+26.0	+ 7.1	+ 1.5	− 45.9	+ 5.0
Shear	−28.2	−45.0	−19.3	+12.6	− 45.8	−664.0

Flexure (1) taken about sheet neutral axis. Flexure (2) taken about wing section neutral axis. Shear perpendicular to grain.

* Positive values are weight savings; negative values are weight increases.

PART II

A general analysis of the structural efficiencies of plastics versus conventional materials considered suitable for aircraft construction has been prepared and the results are illustrated in tables and figures accompanying this article. A number of varying elements of the airplane structure have been selected and analyzed for the most critical types of loading. Sufficient types of elements have been selected to study the comparative efficiencies of the different materials in a major portion of the strength directions. Wherever possible, thickness ratios and weight savings, whether positive or negative, have been tabulated. The materials considered are a paper-base phenol-formaldehyde plastic laminate, a glass-fabric phenol-formaldehyde plastic laminate, aluminum alloy 24S-T, stainless steel 18–8, X4130 steel, magnesium alloy J-1h, and hickory wood. The weight savings tabulated are purely theoretical, based on the analysis, and experimental test checks are not available at this time.

Table I shows the material properties used in analyzing the structural efficiencies when considering a plastic structure wherein the paper or glass plastics must replace the conventional materials. The plastic values are taken from recent tests whereas the steel, aluminum alloy, wood and magnesium alloy values are taken from the ANC-5 Handbook.[1] It is to be noted that the modulus of elasticity for all materials employed in the calculations is the initial modulus. No attempt was made to utilize the tangent modulus in the higher ranges of stress although it is recognized that such values are considerably reduced especially for stainless steel and paper plastic at high stresses. Dural and glass plastic show only a small reduction from the initial modulus as the stresses are increased.

The flexural strength and modulus of elasticity of the hickory is taken parallel to the grain. However, it should be noted that the plastic values are averages of with- and cross-grain results. If unidirectional glass plastic values were used, the modulus of elasticity would be raised to approximately 3,500,000 p.s.i., the tensile strength to 77,000 p.s.i. and the specific gravity to 1.72. However, as in wood, this would lead to very low strength values for the cross-grain glass plastic. Paper plastic does not exhibit the same wide variations with fiber orientation.

Table II shows the weight savings for flat sheet in shear and flexure for all the proposed materials compared to aluminum alloy. It is apparent that both paper and glass offer satisfactory substitutes in flexure as both show substantial weight savings. However, weight increases from 28 to 45 percent are indicated in shear parallel to the grain. Shear perpendicular to the grain, as in wing skin to rib or capstrip attachments, would show similar negative values.

Figure 1 shows the various thickness ratios required for curved plates and thin-walled cylinders in compression and flat plates at equal critical buckling loads for any material substitutions desired. The curved plates and thin-walled cylinders are considered at equal radii, equal width and length. It is noted that 2 curves are plotted on each graph, the first representing the equal weight curve in which the thickness ratios are just proportionate to the density ratios and the second curve represents the equal load relation. Thus, for any density and modulus of elasticity ratio, the required thickness ratios may be selected from these curves for

equal weight and equal load, separately. Naturally the minimum requirement is to select a thickness ratio for equal load, and if this value is less than the thickness ratio required for equal weight as selected from the curves, there is obviously a weight saving for this condition. The weight savings for the condition of paper and glass plastics replacing the conventional materials are shown on Figs. 2 and 3. It is apparent that weight savings are evident only when the plastics replace stainless steel and X4130 steel for curved plates and thin-walled cylinders in compression. Since for curved plates the element represented on the wing or fuselage has a curvature which must be kept constant in accordance with the geometry of the airplane, it is apparent that no weight saving is established by this analysis unless the radii of curvature can be increased. On the other hand, Fig. 3 shows definite weight savings from 5 to 20 percent when glass and paper plastics replace aluminum alloy for flat plates at equal critical buckling loads. Weight savings over stainless steel and X4130 steel are also in evidence. Close observation of these plates will reveal weight savings for the conventional materials other than plastics considered as substitutes for aluminum alloy. This condition (flat sheet) is partially applicable to wing surfaces and empennage surfaces where the radii of curvature are relatively large and the curved sheet approaches flat sheet in design characteristics. However, it should be noted that a comparison based on stiffened sheet would be more useful to the designer than the flat sheet case. Inasmuch as this involves far more complications of analysis, it will be treated somewhat differently later in this paper.

Figure 4 represents plots of the thickness ratios for thin-walled cylinders in torsion for paper and glass plastics replacing aluminum alloy. Here again two curves are shown for each condition, one representing the thickness ratios required for equal weight substitution, and the second representing the thickness ratios required for equal load substitution, at varying diameter ratios. No diameter limitations are represented in this case for it is assumed that the substitute will be designed with increased diameters and thicknesses as necessary. It is apparent that having selected a desired diameter ratio, the thickness ratio on the equal load curve must be picked off first, as the minimum requirement. Similarly a

1—These two graphs show the various thickness ratios required for curved plates and thin-walled cylinders in compression and for flat plates at equal critical buckling loads for any material substitutions desired. 2—Weight saving for curved plates and thin-walled cylinders in compression. 3—Weight saving for flat plates at equal critical buckling load. 4—These two graphs give the thickness ratios for thin-walled cylinders in torsion

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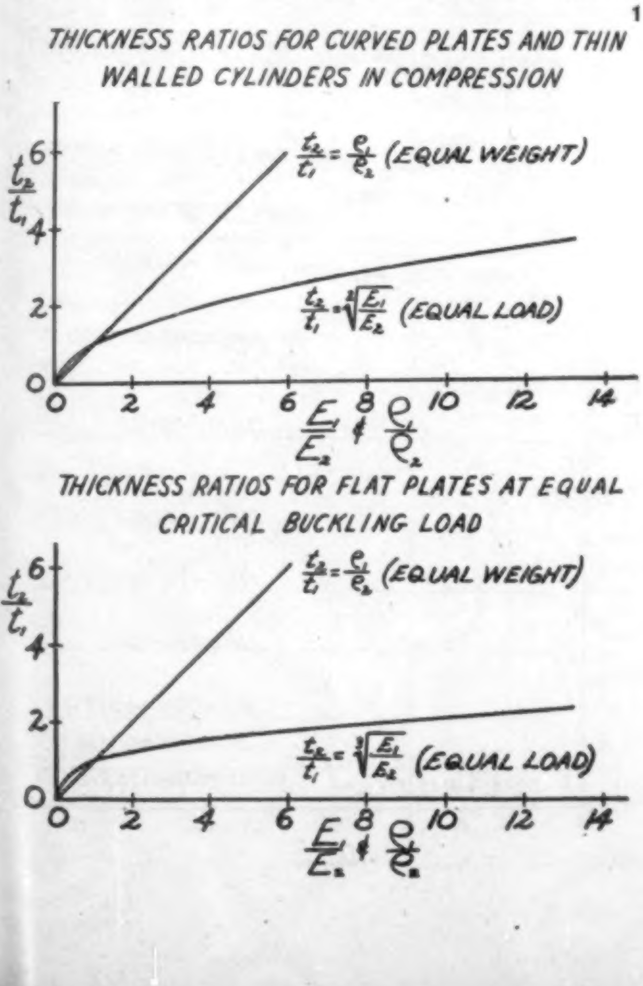

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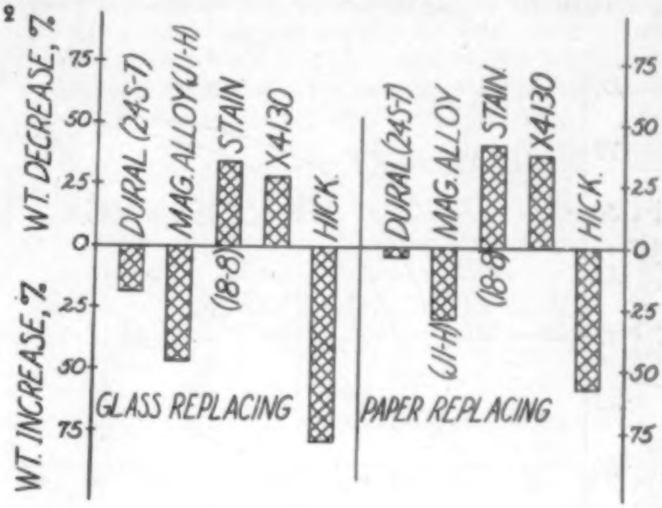

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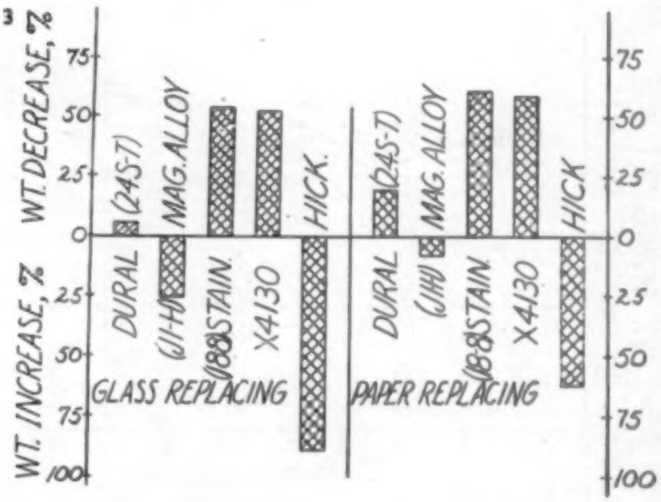

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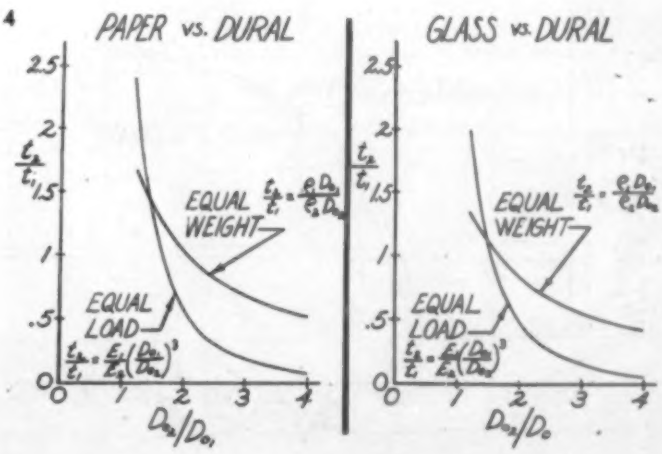

thickness ratio may be then picked off the equal weight curve. If the first is smaller than the second, there is obviously a weight saving. The weight savings may be best shown as the difference in ordinates between the equal weight and equal load curves. Naturally design limitations will dictate the diameter ratio to be selected. The weight savings are shown on Figs. 5, 6, 7 and 8, at varying diameter ratios for the cases of paper and glass plastics replacing the conventional materials. It is observed that for diameter ratios greater than $1^1/_2$ there are substantial weight savings in each case. However, it is also apparent that with increased diameter ratios greater than $1^1/_2$ the thickness ratios begin to drop off, as would be normal in order to keep the moments of inertia from increasing too rapidly.

Figures 9 and 10 show the required diameter and thickness ratios for tubing in bending and compression (long column) when considering paper and glass plastic substitutes for the conventional materials at equal load, weight and deflection. Each curve represents a different material substitution and is plotted against the original diameter to thickness ratios. It is apparent from the plots that the curves approach an asymptote for values of D_{01}/t_1 greater than 20, and for real values of D_{01}/t_1 experienced in service, from 60 to 100, other than thin-walled cylinders, the curves are virtually flat. It remains then in making a substitution for any particular design problem, to compute the original D_{01}/t_1 value and pick off a diameter ratio value from the curve that satisfies the condition of substitution from Fig. 10. Similarly a thickness ratio may be selected from Fig. 9. It is noted that the thickness ratio curves are much flatter than the diameter ratio curves, and reach their asymptotes at very small values of D_{01}/t_1. Data below D_{01}/t_1 values below 10

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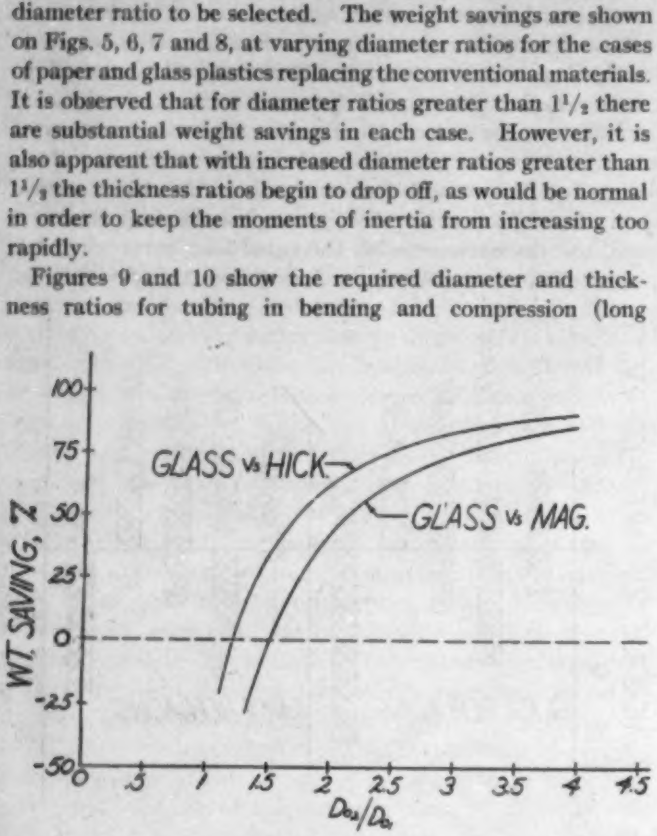

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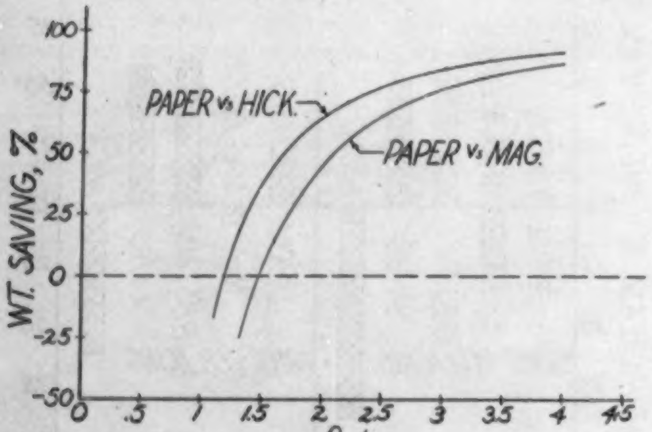

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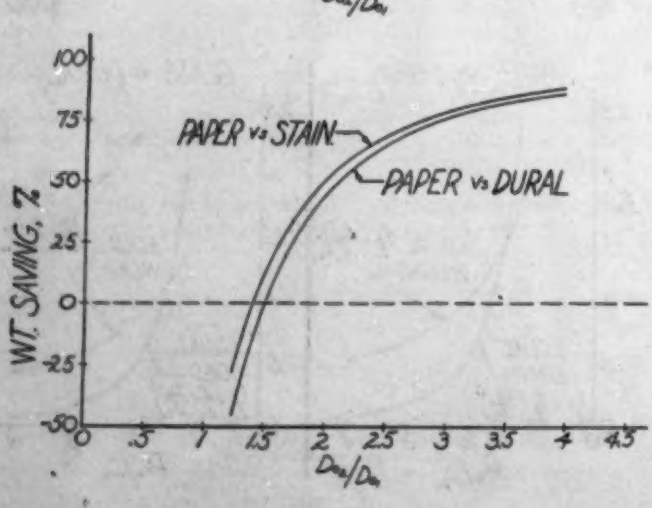

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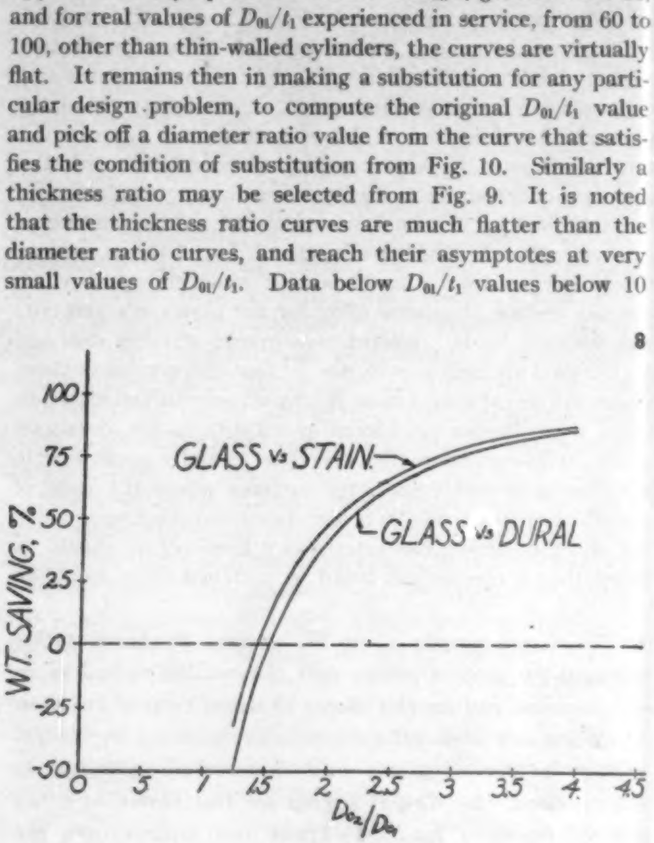

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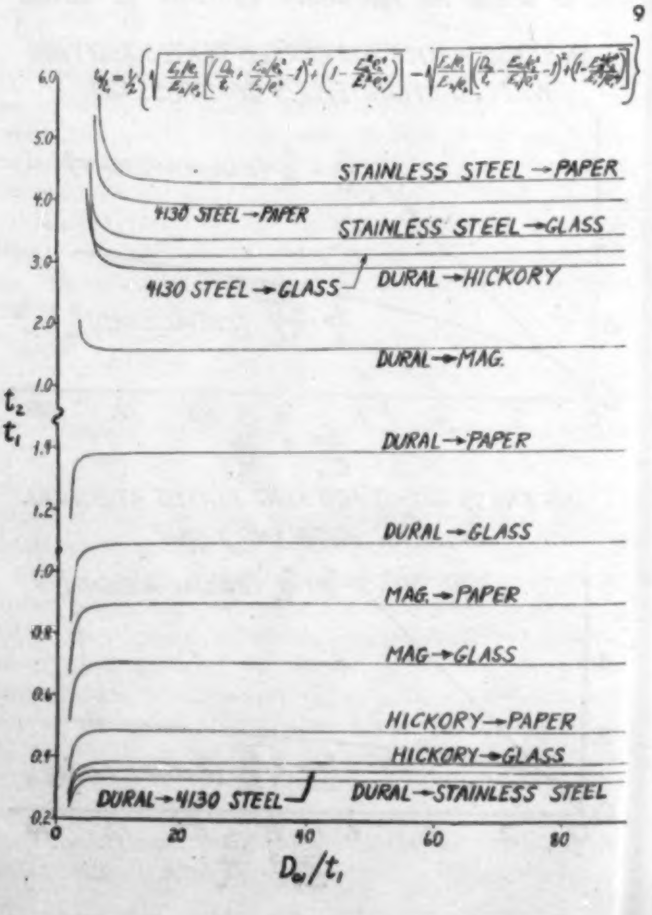

represent imaginary values and are hence inapplicable for design. Similar curves can be constructed for the case of tubing in torsion. In this case the shear modulus of rigidity of the plastic material is critical. The equations for torsion will be identical with those shown on Figs. 9 and 10 with the lone exception of substituting the modulus of rigidity G in place of the modulus of elasticity E.

In attempting to utilize the information just shown with respect to a semi-monocoque type of structure, an analysis was conducted of a paper-base plastic plate stringer combination of a molded type. It was attempted to design the plastic stiffened panel to compare in strength and weight with an aluminum alloy panel which had been tested at the California Institute of Technology.[4] The aluminum alloy panel, together with the test results, is shown on Fig. 11. The panel consisted of .040-in. sheet stiffened with four stringers spaced 5 in. apart, weighed 2.32 lb. and carried an ultimate test load of 24,725 lb. Three designs in plastic were attempted, and the first is shown on Fig. 12. Two types of stringers were designed from ease of computation and are designated as Types I and II on Fig. 12. The first attempt at the panel design consisted of .081-in. sheet stiffened with three stringers of Type I. An effective sheet area of $30 \times t$ was assumed and a critical buckling stress of 11,210 p.s.i. was computed. The computed ultimate failing load was 22,990 lb. and the weight was 2.09 lb. A second attempted panel design is shown on Fig. 13 wherein the sheet thickness was .125 in. and the single stringer of Type II was used. Here again a conservative value of effective sheet width of $30 \times t$ was used. The computed critical buckling stress was 9375 p.s.i., the computed failing load was 16,500 lb., and the weight was 2.35 lb. A third attempt at the design resulted in the panel shown on Fig. 14, wherein the sheet of .125-in. thickness was stiffened with 2 stringers of Type I. Here, the computed critical buckling stress was 8975 p.s.i., the failing load 24,500 lb. and the weight equal to 2.5 pounds.

A summary of the 3 designs plus the tested aluminum alloy panel is shown in Table III. It would appear that a plastic panel with 3 stringers is the most favorable of the group on the basis of failing load divided by total panel weight. How-

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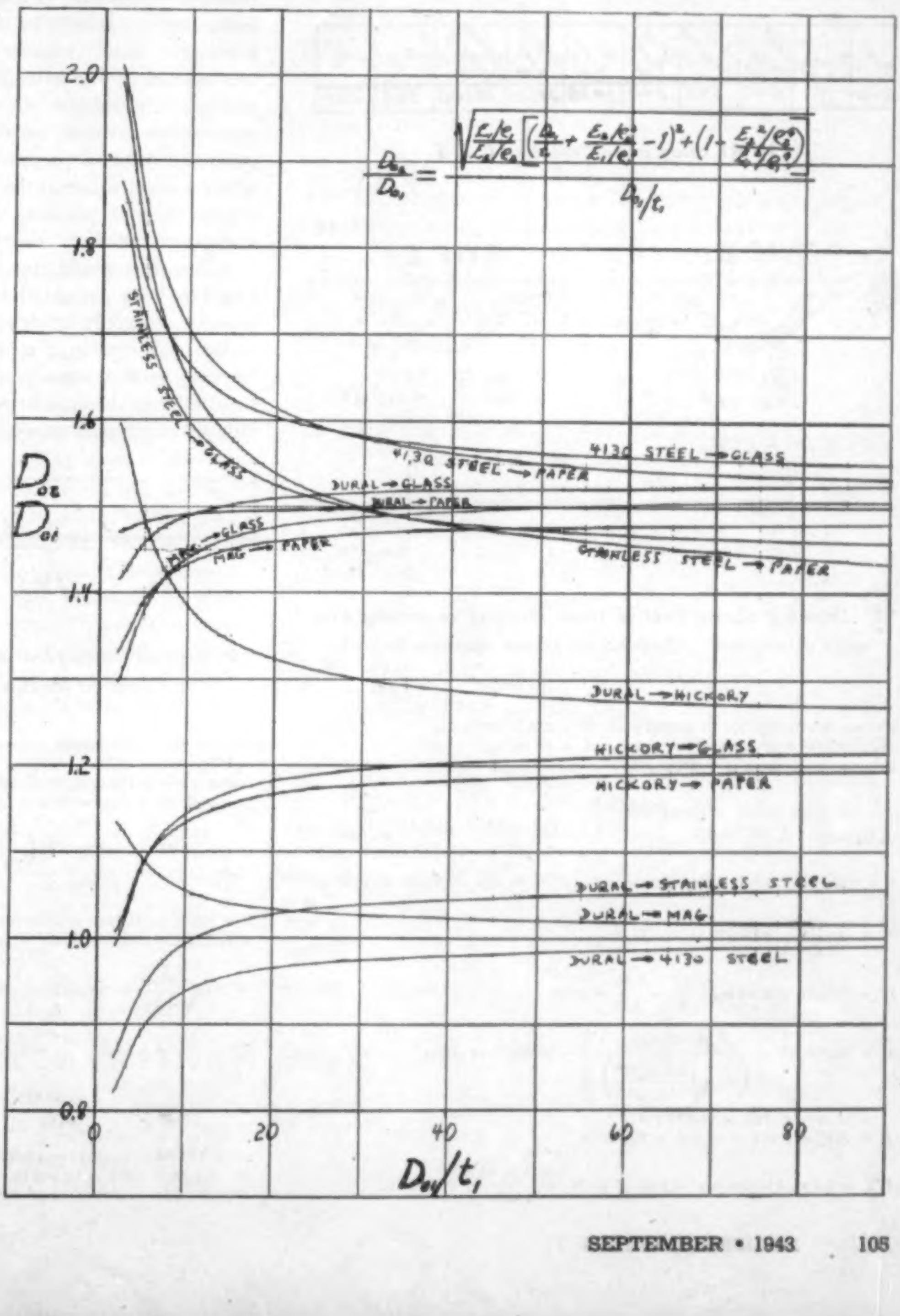

5, 6, 7 and 8—Weight savings for thin-walled cylinders in torsion at varying diameter ratios in cases where paper and glass plastics replace the conventional materials. 9—Tubing in bending and compression (long column); required diameter ratios for equal weight, load and deflection. 10—Tubing in bending and compression (long column); required thickness ratios for equal weight, load, deflection

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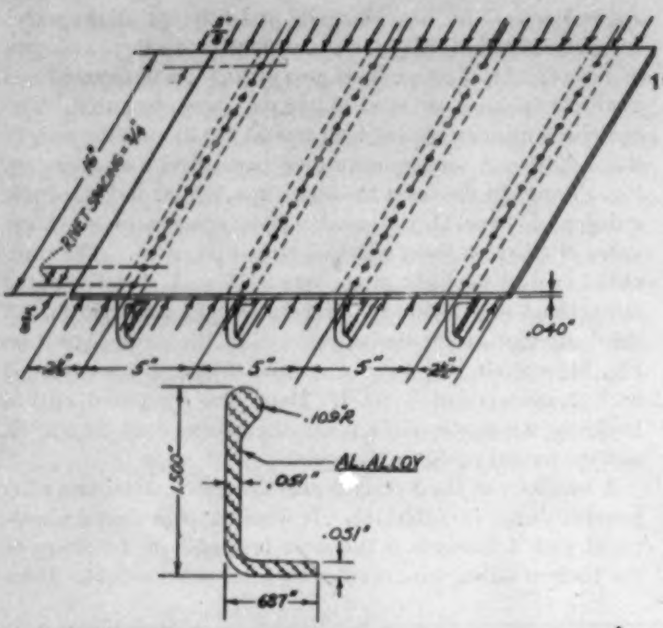

Panel	Panel Length (in)	Sheet Thickness (in)	Bulb Angle Area (sq in)	Sheet Area (sq in)	Total Area (sq in)	Ultimate Load (lb)	Average Stress, σc (lb/sq in)	ρ	L'/ρ
Dural	16	.040	.598	.840	1.438	24725	17200	.563	28.4

11—*Al. alloy panel tested at C. I. T.*

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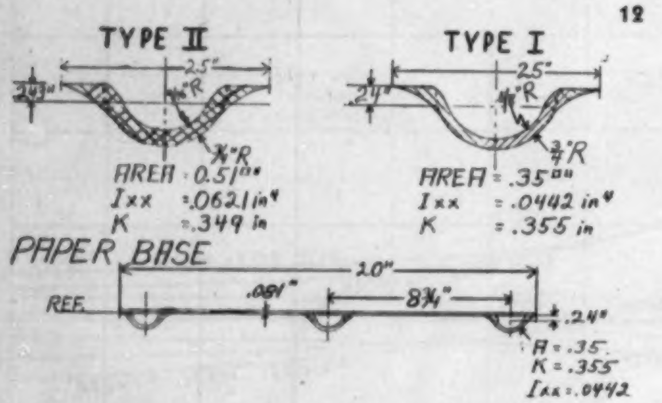

12—*Drawing shows first of three designs in plastic that were attempted. (Legend for figure appears below)*

Assume $We = 30t$, $\sigma_{co} = 16{,}000$ p.s.i., $E = 2.2 \times 10^6$ p.s.i.
Total $We = 2.43 + 2(1.215) + 2.5 \times 3 = 12.36$ in.
Effective area sheet $= 1.001$ sq. in.

$$\text{C. G.} = \frac{3(.35 \times .24) + 1.001\left(-\frac{.081}{2}\right)}{3 \times .35 + 1.001} = \frac{.252 - .0405}{2.051} = \frac{.2115}{2.051} = .103 \text{ in.}$$

$$I = 1.001 \times (.1435)^2 + 3[.0442 + 1.05(.137)^2] = .021 + .1926 = .2136 \text{ in}$$

$$K = \sqrt{\frac{.2136}{2.051}} = \sqrt{.1041} = .323 \text{ in.}$$

$$L' = {}^{16}/\sqrt{3} = 9.24 \text{ in.,} \quad \frac{L'}{K} = \frac{9.24}{.323} = 28.61$$

$$\sigma_c = 16{,}000\left[1 - \frac{.385(28.61)}{\left(\pi\sqrt{\frac{2.2 \times 10^6}{16{,}000}}\right)}\right] = 16{,}000[1 - .299]$$

$= 16{,}000 \times .701 = 11{,}210$ p.s.i.
$P_c = A\sigma_c = 2.051 \times 11{,}210 = 22{,}990$ lb.

$$WT = LA_{TOT} \times \text{density} = 2.67 \times 16 \times \frac{1.355 \times 62.4}{1728} = 2.09 \text{ lb.}$$

ever, closer examination of the results shows that the plastic panel with 2 stringers should satisfy conditions of loading not apparent in this analysis in view of the heavy-gage skin utilized. A greater proportion of the total panel load in compression and shear could be carried by the heavy-gage skin, and fewer tendencies to buckle would probably develop. In addition, the effective sheet width of $30 \times t$ is somewhat conservative and could be increased because a molded joint between the sheet and stringer is continuous and thereby much wider than a riveted joint. This would increase the ultimate computed panel load proportionately and thereby introduce a better failing load-panel weight ratio. In addition there is a closer analogy or approach to the monocoque theory in the 2-stringer panel. It is noted that the stringers are probably not the most efficient design possible. Changing the shape of the stiffeners without increasing the area and thereby increasing the moment of inertia would yield a much stiffer panel. Also similar stiffeners or increases in sheet thicknesses could be introduced at any local point on the panel, as necessary. A 5 to 10 percent increase in the column strength or modulus of elasticity would greatly increase the load-carrying capacity of the entire panel. These points are introduced mainly because the plastic materials do show definite amount of variation in these physical properties noted and can be altered at will by the manufacturer by changing composition without introducing a large deleterious effect upon the material properties in the other directions. Also whereas sheet material thicknesses may be varied at will and continuously in plastics, this trick is almost impossible in metals and definitely uneconomical even if it could be done.

Although it would appear from the data that a very good case has been presented for hickory wood rather than the plastics, especially in designing for curved plates and thin-walled cylinders in compression and flat plates at critical buckling loads, it must be remembered that no material would be suitable in the final structural design unless it had a proper balance of physical properties to withstand loadings in every

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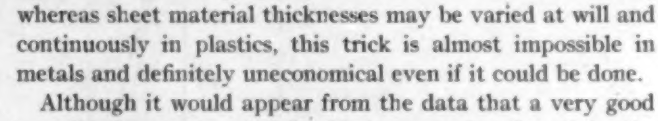

13—*Second attempted panel design with paper base. (Legend for this figure appears below)*

Assume $We = 30t$ simply supported edges, $\sigma_{co} = 16{,}000$ p.s.i.. $E = 2.2 \times 10^6$ p.s.i.
Total $We = 2.5 \times 2 \times 30 \times .125 = 10.0$ in.
Total eff. sheet area $= 10.0 \times .125 = 1.25$ sq. in.

$$\text{Cent.} = \frac{.51 \times .243 - 1.25\left(\frac{.125}{2}\right)}{1.25 + .51} = \frac{.1239 - .0781}{1.76} = .026$$

$I = .0621 + .51(.243 - .026)^2 + 1.25(.026 + .0625)^2$
$I = .0621 + .0239 + .0098 = .0958$ in.^{4}

$$K = \sqrt{\frac{.0958}{1.76}} = \sqrt{.0544} = .233 \text{ in.}$$

$$L' = \frac{16}{\sqrt{3}} = 9.24 \text{ in.,} \quad \frac{L'}{K} = \frac{9.24}{.233} = 39.65$$

$$\sigma_c = 16{,}000\left[1 - \frac{.385(39.65)}{36.84}\right]$$

$= 16{,}000\,[1 - .414] = 16{,}000 \times .586 = 9{,}375$ p.s.i.
$P_c = 1.76 \times 9375 = 16{,}500$ lb.
$WT = (2.50 + .51) \times 16 \times .0489 = 2.35$ lb

direction conceivable in service. In the case of the hickory wood, the shear strength, both perpendicular and parallel to the grain, is low enough to introduce severe weight penalties if this wood were contemplated for use in overall substitution for aluminum alloy. A similar situation exists if the combined loading effects of the wood were analyzed, particularly in shear and compression, such as exists over a major portion of wing skin and capstripping joints.

It is to be emphasized that there are several apparent discrepancies in the tabulation method presented in the analyses shown on Figs. 1 through 14 and Tables I to III. If a low-density material is substituted for the conventional high-density materials, the necessary change in design involving larger unsupported areas with increased thicknesses, fewer stiffeners and general change in disposal of mass reinforcements would result in changes of end fixities of all stiffened and unstiffened plates and overall changes in the rigidity of the structure. In addition, complex variables of second order magnitudes affecting column designs and combined loading effects would be unpredictable without satisfactory test of the simulated test article. The result of neglecting all these variations in making the comparisons would introduce practical errors of considerable magnitudes. As a result the analysis must be viewed as a qualitative rather than a quantitative approach to the design. In any event, the analysis can be best used as a guide of a general sort. It is not intended to guarantee the weight savings indicated by the analysis but rather to generalize on the trends.

PART III

In view of the current interest expressed among aircraft designers of sandwich type materials for use in structural designs, a brief and cursory analysis has been made of composite panels made up of a very low density and relatively thick core or filler, called the web, compressed between 2 faces of relatively high-density thin material, called the flanges.

The general structural theory and basic assumptions are that the web or core will act as a stabilizing member between the 2 faces, or flanges, preventing initial local elastic buckling of the flanges, and delaying permanent Euler buckling until the ultimate compressive material strength of the flanges is developed. It is assumed that a large portion of direct compressive loads is carried by the flanges although the web contribution is not negligible, depending on the relative magnitude of compressive yield strength, modulus of rupture, modulus of shear rigidity, modulus of elasticity and Poisson's ratio of the 2 materials, web and flange. The lateral expansion of the web is assumed to be uniform, whereas the shear and cross tensile deformations affect the web only. In general the web must be stiff enough in shear to exploit the superior strength of the flanges when the panel bends as a unit, and also to provide sufficient continuous support against premature crinkling of the flange material. Therefore, the shear rigidity of the web will be critical for Euler buckling, whereas the modulus of elasticity in bending will be critical for local crinkling of the face material.

However, with a satisfactory web material the local moments of inertia of the cross section will be greatly increased and thereby enhance the stability of the panel under compressive loads. Possibilities of increased flexural and torsional strength are also indicated by virtue of the increased moment of inertia as well as the stabilization tendency of the web to allow the flange to develop its full shear strength as a simple or rigid supported panel. In short, for a properly designed sandwich panel, a given gage and size of flange material will develop a large increase of end compressive load for a small

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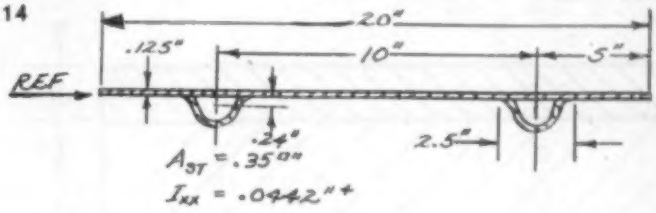


14—*Third attempt at panel design with paper base. (Legend for this figure appears below)*

$We = 30t$ simply supported edges, $\sigma_{co} = 16{,}000$ p.s.i.. $E = 2.2 \times 10^6$ p.s.i.
Total $Wc = 90 \times .125 + 2 \times 2.5 = 16.25$ in.
Total eff. sht. area $= 16.25 \times .125 = 2.031$ sq. in.
Total area $= 2.031 + 2 \times .35 = 2.731$ sq. in.

$$\text{C. G.} = \frac{2 \times .35 \times .240 + 2.031(-.0625)}{2.731} = \frac{.168 - 127}{2.731} = .015 \text{ in.}$$

$$I = 2[.0442 + .35(.24 - .015)^2] + 2.031 \times (.0625 + .015)^2 \text{ in.}^4$$
$$I = 2(.0442 + .0178) + .008 = .1321 \text{ in.}^4$$

$$K = \sqrt{\frac{.1321}{2.731}} = \sqrt{.04837} = 220 \text{ in.}$$

$$L'/K = \frac{9.24}{.220} = 42.0$$

$$\sigma_c = 16{,}000 \left[1 - \frac{.385(42)}{36.84}\right]$$

$\sigma_c = 16{,}000\ [1 - .439] = 8975$ p.s.i.
$P_c = 8975 \times 2.731 = 24{,}500$ lb.
$WT = (2.5 + .7) \times 16 \times .0489 = 2.5$ lb.

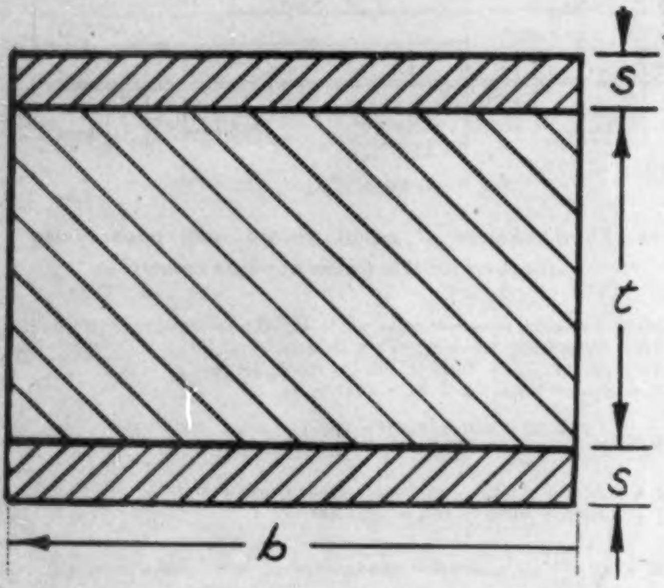
TABLE III.—SUMMARY OF SHEET-STRINGER PANELS

Sheet material	*Stringer material*	*Number of stringers*	*Sheet area sq. in.*	*Stringer area sq. in.*	*Computed sheet load (effective) lb.*	*Ultimate computed panel load lb.*	*Ultimate test load of panel lb.*	*Ultimate average stress (test) p.s.i.*	*Ultimate buckling stress (computed) p.s.i.*	*Wt. of panel lb.*
Al alloy (24-ST)	Al alloy (24-ST)	4	.840	.598	....	....	24,725	17,200	....	2.32
Paper plastic	Paper plastic (Type I)	3	1.62 (actual) 1.001 (effective) (30t)	1.05	11,220	22,990	....	....	11,210	2.09
Paper plastic	Paper plastic (Type II)	1	2.50 (actual) 1.25 (effective) (30t)	0.51	11,720	16,500	....	....	9,375	2.35
Paper plastic	Paper plastic (Type I)	2	2.50 (actual) 2.031 (effective) (30t)	0.70	18,217	24,500	....	....	8,975	2.50

increase of weight, namely, that due to web material alone. Similarly, with the addition of the web, the flange gage may be reduced considerably and the resulting sandwich will carry a greater compressive load than the previous heavy gage flange alone, assuming equal weights for both panels. In addition, distortion and buckling of the flanges, simulated as fuselage or wing skin, are eliminated within the range of Applied Limit Design Loads. This is a matter of great concern to designers of modern combat aircraft that must fly at very high speeds in the region of airflow compressibility where local distortions in the skin form areas of high turbulence in the airflow. The resulting disturbance of airflow tends to cause completely unpredictable performance characteristics and may even lead to structural failures.

The current interest in this type of construction is due to the use of composite material of this type in a well-known light bomber wherein it appears that a weight saving of considerable quantity may have been achieved. This type of construction was attempted by the Germans and British fully 10 years ago without any particular success. It has been apparent from current usage that the best efficiencies for this type of construction have been achieved in designs of cylindrical nature such as the fuselage. The analogy to a pure monocoque construction is far more apparent in this case than in any other in view of the large diameter-thickness ratios used in the fuselage design or in large torsion boxes. The case analyzed in this paper uses a core material of balsa wood which fulfills the conditions of a stabilizing member satisfactorily. However, it is to be noted that a purely synthetic material such as cellular cellulose acetate of expanded fibers has been partially developed and may soon be used in place of the balsa suitably. In addition to balsa, there are at least 2 other low-density woods available in the North American continent for use in this construction.

15



15—*General analysis of sandwich design. (Notation for figure appear below)*

s = face thickness
t = core thickness
b = width of column
L = length of column
K = overall fixity coefficient
$L_1 = \frac{L}{K}$ = effective column length
P_E = Euler buckling load
E_s = flexural modulus of elasticity of face (flange)
E_{cs} = compressive modulus of elasticity of face (flange)
E_o = flexural modulus of elasticity of core (web)
E_{co} = compressive modulus of elasticity of core (web)
f_{cs} = compressive stress in face
f_{co} = compressive stress in core
e_{cs} = compressive strain in face
e_{co} = compressive strain in core
p_{cs} = compressive load carried by face
p_{co} = compressive load carried by core
F_{cys} = allowable compressive yield stress of face
F_{cyo} = allowable compressive yield stress of core
P_{cy} = total allowable compressive load of sandwich
D_s = density of face
D_o = density of core
μ_s = Poisson's ratio for face
μ_o = Poisson's ratio for core
$(W/A)_o$ = weight per sq. ft. of core (web)
$(W/A)_s$ = weight per sq. ft. of face (flange)
$\frac{EI/b}{W/A}$ = general stiffness – weight parameter

Buckling analysis

Using the notation shown on Fig. 15, the following equations are set up to determine an expression for the buckling load of a sandwich panel.

$$\left(\frac{W}{A}\right)_o = D_o t \tag{1}$$

$$\left(\frac{W}{A}\right)_s = D_s(2S) \tag{2}$$

$$\left(\frac{W}{A}\right)_{o+s} = \frac{W}{A} = 2D_sS + D_ot \tag{3}$$

$$\frac{EI}{b} = \frac{E_ot^3}{12} + 2E_s\left\{\left(\frac{t}{2}+\frac{S}{2}\right)^2 S + \frac{S^3}{12}\right\} \tag{4}$$

$$= \frac{E_ot^3}{12} + \frac{E_sSt^2}{2} + E_stS^2 + \frac{2}{3}E_sS^3$$

When $t \gg s$, the 4th term above is less than 1 percent of total, so neglect the term $\frac{2}{3}E_sS^3$. Then,

$$\frac{EI/b}{W/A} = \frac{\frac{E_ot^3}{12} + \frac{E_sSt^2}{2} + E_stS^2}{2D_sS + D_ot} \tag{5}$$

From Equation 3

$$S = \frac{W/A - D_ot}{2D_s} \tag{6}$$

and

$$t = \frac{W/A - 2D_sS}{D_o} \tag{7}$$

Substituting in Equation 4, the stiffness function in terms of core thickness t is

$$\frac{EI}{b} = \frac{E_ot^3}{12} + \frac{E_st^2}{2}\left[\frac{W/A - D_ot}{2D_s}\right] + E_st\left[\frac{W/A - D_ot}{2D_s}\right]^2$$

$$= \frac{E_st}{4}\left[\frac{1}{D_s^2}\left(\frac{W}{A}\right)^2 + \frac{t}{D_s}\left(1 - \frac{2D_o}{D_s}\right)\left(\frac{W}{A}\right) + t^2\left(\frac{1}{3}\frac{E_o}{E_s} - \frac{D_o}{D_s} + \frac{D_o^2}{D_s^2}\right)\right] \tag{8}$$

In terms of the face thickness S, the stiffness function is

$$\frac{EI}{b} = E_o\left[\frac{1}{12D_o^3}\frac{E_o}{E_s}\left(\frac{W}{A}\right)^3 + \frac{S}{2D_o^2}\left(1 - \frac{E_o/D_o}{E_s/D_s}\right)\left(\frac{W}{A}\right)^2 + \frac{S^2}{D_o}\left(\frac{E_o/D_o^2}{E_s/D_s^2} - 2\frac{D_s}{D_o} + 1\right)\frac{W}{A} + 2S^3\frac{D_s}{D_o}\left(\frac{D_s}{D_o} - 1 \frac{-1}{3}\frac{E_o/D_o^2}{E_s/D_s^2}\right)\right] \tag{9}$$

Since Equations 8 and 9 represent Euler buckling parameters, the following relationships are noted[3]:

$$P_E = \frac{\pi^2 EI}{L_1^2} \tag{10}$$

$$\therefore \; \frac{EI}{b} = \frac{P_E L_1^2}{\pi^2 b} \tag{11}$$

Equations 8 and 9 are plotted on Figs. 16 and 17, considering the 2 combinations of Alclad + balsa, and Fiberglas + balsa.

Panel failure by material compression limitations

In order to determine the cut-off limitations where a sandwich panel will fail in pure material compression at either the face or core before developing its maximum buckling load, the following expressions are derived for a panel in end compression, without edge support.

$$E_{cs} = \frac{f_{cs}}{\epsilon_{cs}} \tag{12}$$

$$E_{co} = \frac{f_{co}}{\epsilon_{co}} \tag{13}$$

Assuming equal strains on face and core simultaneously,

$$\epsilon_{co} = \epsilon_{cs} \tag{14}$$

$$f_{cs} = \frac{p_{cs}}{2bS} \tag{15}$$

and

$$f_{co} = \frac{p_{co}}{bt} \tag{16}$$

Then, summing up the face and core loads, we have

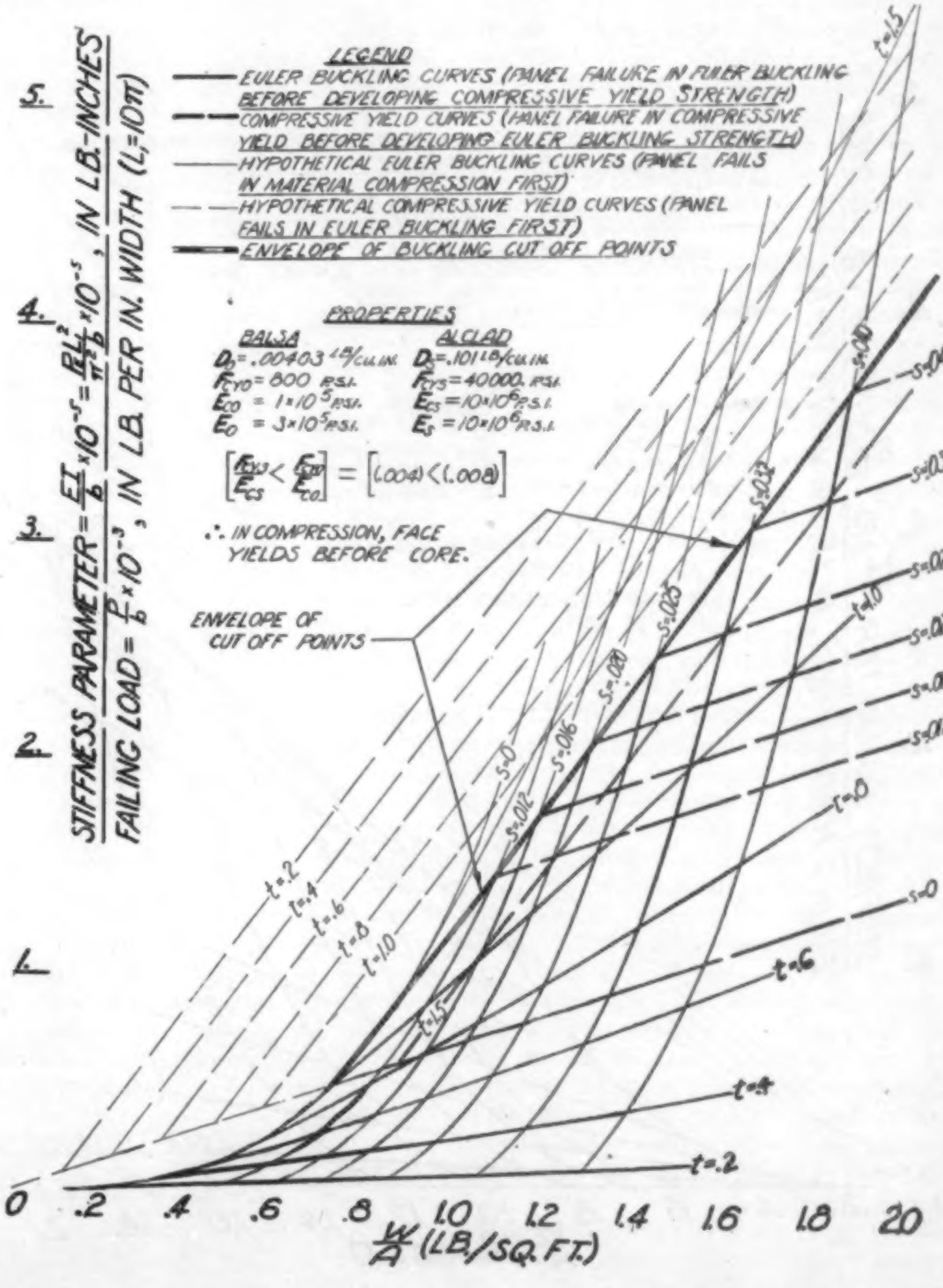
$$p_{cs} + p_{co} = p_c \tag{17}$$

Substituting,

$$2bSf_{cs} + btf_{co} = p_c \tag{18}$$

Dividing through by b,

$$\frac{p_c}{b} = 2Sf_{cs} + tf_{co}. \tag{19}$$



16—Sandwich panel failing load (Euler buckling and compressive yield) vs. weight per sq. ft. loaded in end compression without edge support—24 S-T Alclad face and balsa core

From Equation 14,

$$\frac{f_{cs}}{E_{cs}} = \frac{f_{co}}{E_{co}} \tag{20}$$

Then for each face and core material combination,

$$\frac{F_{cys}}{E_{cs}} \gtreqless \frac{F_{cyo}}{E_{co}} \tag{21}$$

depending on the following conditions:

Case A. The core yields first.
Case B. Both core and face yield simultaneously.
Case C. The face yields first.

In Case A,

$$\frac{F_{cys}}{E_{cs}} > \frac{F_{cyo}}{E_{co}}$$

using Equations 19 and 20

$$\frac{P_{cy}}{b} = 2S\,\frac{E_{cs}}{E_{co}}\,F_{cyo} + tF_{cyo}; \tag{22}$$

substituting Equation 7 for t,

$$\frac{P_{cy}}{b} = F_{cyo}\left[2S\left(\frac{E_{cs}}{E_{co}} - \frac{D_s}{D_o}\right) + \frac{W/A}{D_o}\right], \tag{23}$$

representing the total compressive yielding load per unit width of the panel as a function of W/A, for various face thicknesses. For various core thicknesses, substituting Equation 6 in Equation 22, the expression is

$$\frac{P_{cy}}{b} = F_{cyo}\left[t\left(1 - \frac{E_{cs}/D_s}{E_{co}/D_o}\right) + \frac{E_{cs}}{E_{co}}\,\frac{W/A}{D_s}\right] \tag{24}$$

For Case C,

$$\frac{F_{cys}}{E_{cs}} < \frac{F_{cyo}}{E_{co}}$$

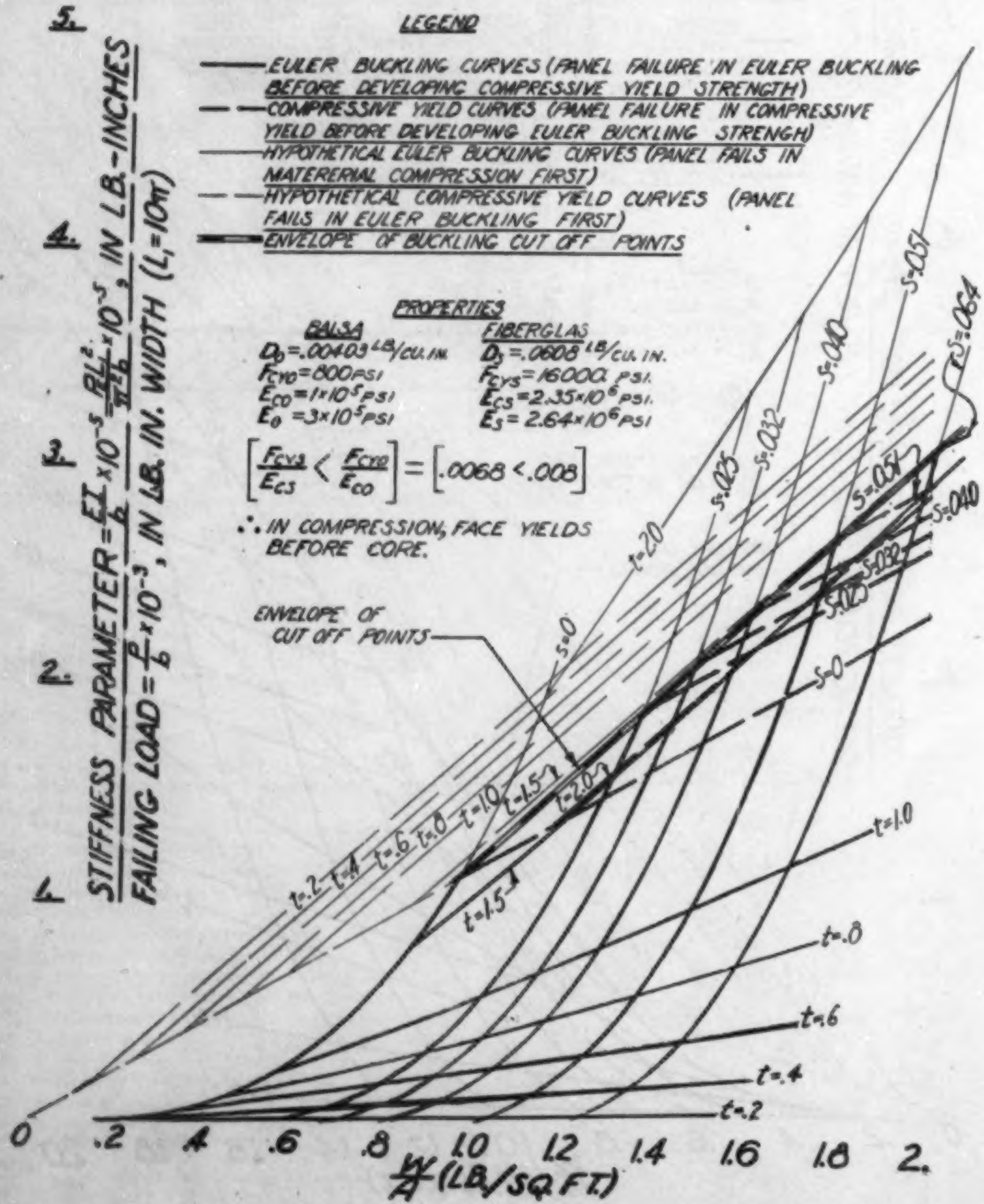
where the face yields first, the total compressive yielding load per unit width of panel as a function of W/A, for various face thicknesses, is

$$\frac{P_{cy}}{b} = F_{cys}\left[2S\left(1 - \frac{E_{co}/D_o}{E_{cs}/D_s}\right) + \frac{E_{co}}{E_{cs}}\,\frac{W/A}{D_o}\right] \tag{25}$$

and for various core thicknesses, the expression is

$$\frac{P_{cy}}{b} = F_{cys}\left[t\left(\frac{E_{co}}{E_{cs}} - \frac{D_o}{D_s}\right) + \frac{W/A}{D_s}\right] \tag{26}$$

(*Please turn to page 148*)



17—*Sandwich panel failing load (Euler buckling and compressive yield) vs. weight per sq. ft. loaded in end compression without edge support—Fiberglas face and balsa core*

Deformation under load of rigid plastics[1]

by ROBERT BURNS[2]

RIGID organic materials possessing high resistance to deformation under load have been an essential part of precision electrical apparatus for many years. Of major importance are hard rubber and the phenolic thermosetting group including molded parts and laminates. Deformation under load, sometimes referred to as "cold flow," has always been a problem in hard rubber and in fact was an important incentive in the development of the phenolics since the latter, because of their thermosetting characteristic, retained substantial rigidity at high service temperatures.

In the early thirties, with the introduction of many of the so-called thermoplastics and the inherent possibilities of injection and extrusion processes, design engineers became interested in the merits of these newer materials, first with regard to the need for color in artistic designs and later for the more utilitarian uses. Since the start of the war, and the necessity for more flexibility in the substitution of materials, the thermoplastics have been given serious consideration for insulating and structural uses. For these purposes the designer must know how they will perform from a deformation standpoint.

Types of deformation

Change of dimension under pressure may be principally simple plastic deformation, as in hard rubber, polystyrene, methacrylate plastic, rigid vinyl compounds or any nonhygroscopic material, or it may be a complex combination of shrinkage or swelling superimposed on plastic deformation as in the case of cellulosic derivatives. In these materials the situation is further complicated by the fact that contained moisture has a pronounced effect on the plastic deformation.

The permanence and rigidity of most assembled apparatus involving plastics will depend upon the flow characteristics of the materials employed, how they are assembled and subsequently used. The data presented here will be principally directed to determining what are likely to be safe assembly practices, considering that most thermoplastics are high in deformation when compared to the thermosetting materials.

The device used for this study is the parallel-plate constant force device described in A.S.T.M. Tentative Method of Test for Deformation of Plastics Under Load at Elevated Temperatures (D621–41T).[3] The test specimen, conditioned if necessary, is placed between the parallel plates and the change in thickness observed at any desired combination of time, pressure and temperature.

The parallel plate type of deformation test has been chosen for the following reasons: *a*) it is far less difficult than the variable-force constant-deflection system which is implicit in most design applications; and *b*) experience has shown that test results can be used with almost equal facility in predicting service performance. In his paper on relaxation, Hopkins[4] has described a variable-force constant-deflection method for determining relaxation of elastomers, but the problem is substantially more difficult with the so-called rigid materials, that is, materials possessing negligible elastic deformation.

As a practical design problem, a switching apparatus now using laminated thermosetting material of the phenolic type can be considered as an example. The apparatus consists essentially of metallic contacting members insulated from one another by thin sheets of the insulating material. Laboratory tests and field experience have shown that during the service life of the device, the individual insulators must not change in thickness more than 2 percent due to deformation, shrinkage or both, since greater changes will result in maladjustment of the contacts in service and consequent failure.

Let it be assumed that for engineering reasons, or perhaps due to wartime shortages, it is desired to replace the phenolic material with a thermoplastic. The latter materials are by definition inferior to the phenolics in resistance to deformation at high service temperatures; therefore compromises in other directions must be made to assure satisfactory performance.

So long as the thermosetting insulators were employed, exact knowledge of service temperatures was not required, but with the thermoplastics a more precise estimate must be made of the maximum temperature to which the apparatus will be subjected during its service life. Since the great majority of the thermoplastics are objectionably soft at temperatures in excess of 175° F., the differences between them at any reasonable upper indoor service temperature, for example, 120° F. or 140° F., while definitely sizable, are not sufficiently large to represent the difference between success and failure because the flow is too great in all cases when compared to thermosetting materials. Consequently it is a reasonable approach to choose whichever thermoplastic is most desirable from other standpoints, and to compensate for its relatively high flow by reducing the pressures used in assembly to a point where the deformation is of the same order as that obtained with the thermosetting materials.

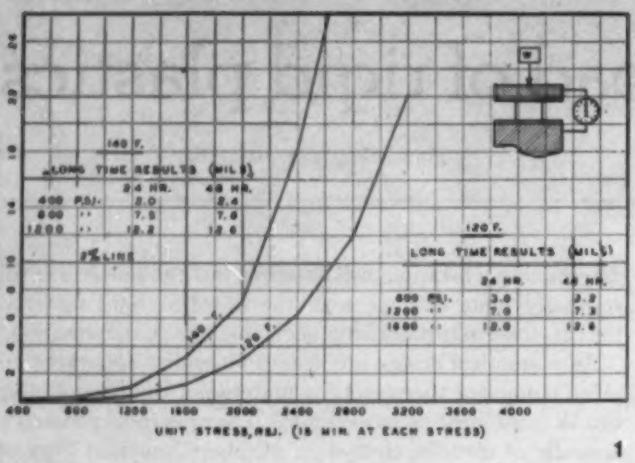
Assuming the substitute material has been chosen and the upper service temperatures decided upon, the apparatus illustrated in A.S.T.M. Tentative Method D621 can be used to determine the maximum permissible pressure. Although it would be feasible to use the A.S.T.M. method making a 24-hr. test at each of many pressures, such procedure would be time-consuming and unnecessary. Satisfactory results can be obtained in a much shorter time by the following method: the first step consists of a relatively rapid exploration of the flow properties. This is done by placing a specimen in the machine at any desired temperature and, starting with a low pressure, say 400 p.s.i., increase the load in suitable increments (for example, 400 p.s.i.), holding for 15 min. at each increment, until the capacity of the machine (4000 p.s.i.) is reached or until the 2 percent limit is passed. The flow data (subtracting the elastic deformation) are plotted as ordinates and the stresses as abscissae. This curve gives a general picture of the deformation properties of the plastic at that temperature and also will disclose any sharp yield points as a function of pressure. A family of flow-pressure curves at various temperatures provides a complete short-time flow picture and will show the presence of a yield point, if any, as a

[1] This paper was presented before the American Society for Testing Materials in Pittsburgh, Penna., on July 1, and is published here through the courtesy of that Society.

[2] Bell Telephone Laboratories, Inc.

[3] 1942 Book of A.S.T.M. Standards, Part III, p. 1226; MODERN PLASTICS *19*, 72 (Feb. 1942).

[4] Irving L. Hopkins, "Relaxation of Rubber-Like Materials," *Preprint No. 87a*, presented at the Forty-sixth Annual Meeting of the American Society for Testing Materials, held in Pittsburgh, Pa., June 28 to July 1, 1943.



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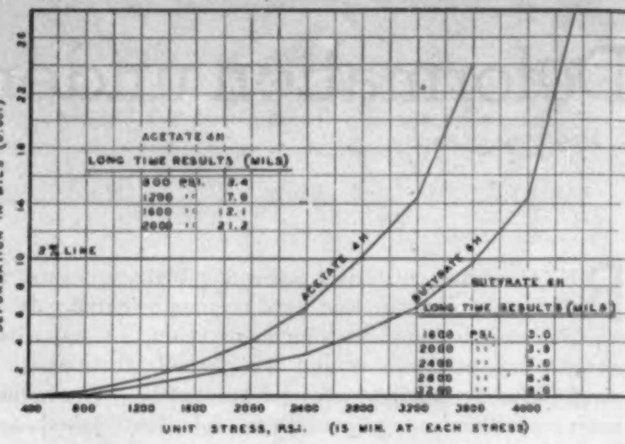

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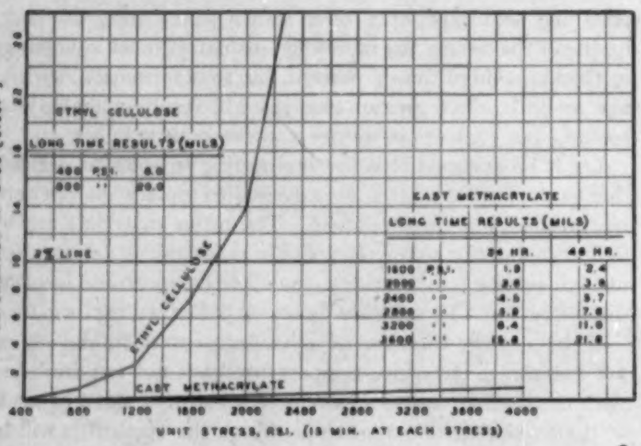

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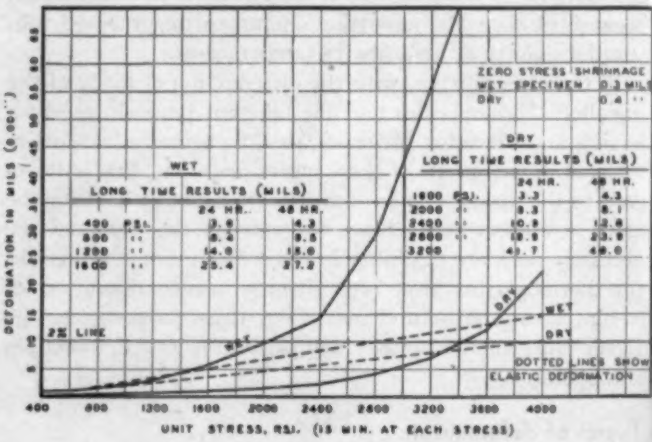

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1—Cellulose acetate butyrate—H. One-half inch cube specimens, no conditioning. Specimens exposed to test temperature 1/2 hr. before applying first load. 2—Cellulose acetate and cellulose acetate butyrate (hard grades). No conditioning. All results at 120° F. Long-time values are for 24 hr. only. 3—Ethyl cellulose and cast methacrylate. No conditioning. All results at 120° F. 4—Cellulose acetate—4 H. "Wet" specimens exposed to 90 percent relative humidity at 85° F. for 48 hr. prior to testing. "Dry" specimens dried at 120° F. for 48 hr. period prior to testing. All results at 120° F.

function of temperature. With the exception of cast sheeting, test specimens used for this study were 1/2-in. cubes cut from 1/2 by 1/2 by 5-in. test bars, compression molded.

Figure 1 illustrates the short-time flow properties of cellulose acetate butyrate of medium hardness, H. Elastic deformation is not included, since in any practical application the elastic deformation is taken up immediately by the assembly pressure. It will be seen that this particular material exhibits no sharp yield at practical pressures and for temperatures of 120° and 140° F.

A line is now drawn at the ordinate representing 2 percent deformation. It is obvious that all pressures beyond the intercept of this line with the flow curves can be omitted from further consideration. A group of pressures within the 2 percent area are chosen arbitrarily for further exploration to determine long-time flow. These tests are occasionally continued for 48 hr., although experience has shown that a large portion of the flow takes place in less than 24 hours. Using the long-time flow data, the design engineer can be supplied with suitable assembly pressures.

Figure 2 gives short-time pressure-deformation curves and long-time deformation values for cellulose acetate of hardness 4H and cellulose acetate butyrate of hardness 6H. Figure 3 gives similar data on ethyl cellulose and cast methacrylate resin. Figure 4 illustrates flow of cellulose acetate of hardness 4H, under "wet" and "dry" conditions. The zero-pressure shrinkage on drying is also given. From these data a rough estimate of flow *per se*, flow enhanced by the plasticizing effect of water, and change of dimensions due to shrinkage can be made. In most cases the zero-pressure shrinkage is negligible. This type of analysis is of interest only in hygroscopic materials.

The choice of stresses for the long-time tests is suggested largely by experience with a given material. The data in Fig. 2 illustrate the futility of any broad generalizations. In the case of a material where no previous experience is at hand, a reasonable starting point is one-half of the stress which produced the maximum permissible deformation in the short-time test. The data also emphasize the importance of time in any consideration of flow phenomena; hence the difficulty of applying rapid tests (such as ball indentation) in plastics design problems.

It is not the intention of the foregoing to present final engineering data on the materials tested nor to pass on their relative merits. The principal purpose here is to outline what is believed to be a useful procedure to obtain design information. The choice of temperatures, limiting values of permissible flow, and how the specimens should be conditioned, if at all, are all factors determined by the particular apparatus in mind, and where it is to be used. In addition, many thermoplastics are available in a wide variety of hardnesses, permitting the materials engineer substantial latitude.

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TECHNICAL BRIEFS

Abstracts of articles on plastics in the world's scientific and engineering literature relating to properties and testing methods, or indicating significant trends and developments

Engineering

FIREPROOFING COTTON AND WOOLEN FABRICS. R. V. Tuyle. Am. Dyestuff Reporter *32*, 297–301 (July 5, 1943). A satisfactory method of fireproofing cotton and woolen fabrics has been developed by the Chemical Warfare Service. The treatment consists of impregnating the fabric with a dispersion of antimony trioxide (Sb_2O_3) in a methyl ethyl ketone solution of Vinylite VYHH, drying and finishing. When placed directly in a flame, fabric treated in this way will char but will not flame or burn. The fire-resistant properties of the fabric are not affected by washing or dry cleaning. The tensile strength and aging characteristics of the cloth are not materially affected by the treatment. Test methods are described.

STEEL, PLASTICS AND ZINC USED IN COMBINATION DIE SET. J. C. Wright. Iron Age *151*, 68–70 (June 17, 1943). The time of forming and numbering a B-17 bomber part has been reduced more than 75 percent by the use of a 2-step progressive die in which blanking, piercing, forming and numbering operations are performed. Plain and alloy steels, two kinds of plastic and Kirksite are used for the construction of these unusual dies. The plastics are (1) phenolic resin with walnut shell flour and woodflour fillers and (2) paper-laminated phenolic resin.

OUTBREAK OF DERMATITIS FROM AIRPLANE-ENGINE COVERS. L. Schwartz and S. M. Peck. U. S. Pub. Health Repts. *58*, 625–31 (1943). An outbreak of dermatitis occurred among workers employed in the manufacture of airplane engine covers from a special grade of Pliofilm. The cause was traced to a light stabilizer, R.M.F., used in the film. This chemical is a primary irritant and a sensitizer.

DERMATITIS FROM RESIN GLUE IN WAR INDUSTRIES. L. Schwartz, S. M. Peck and J. E. Dunn. Public Health Rep. *58*, 899–904 (June 11, 1943). The increased use of resin glues in industry has resulted in an increase in occupational dermatitis among workers. The glues may be roughly classified as follows: (1) protein glues, (2) natural resin glues, (3) synthetic resin glues and (4) combinations of the foregoing. The synthetic resins cause the majority of the cases of dermatitis. The incompletely cured resins and the catalysts are responsible for most of the irritation. The particular ingredients which have been found to cause occupational dermatitis are discussed and examples cited.

Chemistry

THE HEAT OF POLYMERIZATION OF SOME VINYL COMPOUNDS. G. Goldfinger, D. Josefowitz and H. Mark. J. Am. Chem. Soc. *65*, 1432–3 (July 1943). The molar heats of polymerization of styrene, methyl methacrylate and vinyl acetate are reported as 15,000 ± 470, 7900 ± 400 and 8000 ± 400 calories, respectively.

THE POLYMERIZATION OF METHYL METHACRYLATE IN THE PRESENCE OF BENZOYL PEROXIDE. G. V. Schulz and F. Blaschke. Z. phys. Chem. B *51*, 75–102 (Jan. 1942). The reaction mechanism was investigated by determining the velocity and average degree of polymerization as functions of concentration, temperature and time. The primary reaction proceeds in 2 steps. An intermediate product is formed of peroxide and monomer and this is changed to the active primary product. Then a growth reaction occurs in which more molecules are taken up. Similarly 2 reactions are effective at the breaking of the chain. The reaction constant and the course of the reaction were determined.

MEASUREMENT OF CHEMICAL DAMAGE IN NYLON TEXTILES. J. Boulton and D. L. C. Jackson. J. Soc. Dyers & Colourists *59*, 21–6 (Feb. 1943). A viscosimetric method for the evaluation of chemical damage in nylon is proposed. The most suitable solvent is *m*-cresol, and a study of the flow of nylon solutions in this liquid has been made. Suitable dimensions for an efflux type viscometer are given, and a routine method is specified for the measurement of nylon fluidities. Data for degradation due to light exposure and acid attack are given, and a smooth relation is shown to exist in both cases between tensile strength and fluidity. The first 50 percent of chemical damage due to Fadeometer exposure with the sample of nylon used corresponds to a rise of 15 fluidity units, and the same degree of damage due to mineral acid attack corresponds to a rise of 30 units. The fluidity unit is reciprocal poise × 100. The fluidity of 30 undamaged yarns of recent spinning varies between 20.0 units and 22.9 units.

EFFECTS OF PETROLEUM PRODUCTS ON SYNTHETIC VULCANIZATES. R. E. Morris, R. R. James, E. B. Caldwell, and T. A. Werkenthin. Rubber Age *53*, 335–38 (July 1943). The effects of iso-octane, a gasoline-aromatic blend and turbine oil at 82° F. and of turbine oil at 190° F. on 10 Buna N, 2 Thiokol and 4 Neoprene synthetic rubbers are reported. The properties considered were tensile strength, elongation, volume change and diffusion. The materials were immersed in the petroleum products for 2 weeks. None of the rubbers were plasticized.

Properties

THE THERMAL CONDUCTIVITY OF LAC AND LAC MOLDING COMPOSITIONS. G. N. Bhattacharya. Indian J. Phys. *16*, 249–59 (1942). The thermal conductivities of several lacs, synthetic resin modified shellacs and several shellac molding compounds were measured, both desiccated and after immersion in water for 24 hours. The thermal conductivity of shellac at 33° C. is 0.00061 in c.g.s. units and is not affected by immersion in water. This value is the same order of magnitude as phenolic resins and paraffin. Only the filled compounds increased in conductivity on water immersion.

ON ANOMALIES OF ELASTICITY AND FLOW AND THEIR INTERPRETATIONS. R. Simha. J. Phys. Chem. *47*, 348–63 (Apr. 1943). Elastic relaxation, elastic after-effect and creep phenomena in inorganic glasses and high polymers are considered. The behavior of such materials is characterized by the existence of a whole set or a distribution of mechanical relaxation frequencies. Similar conclusions have been reached on the basis of the dielectric dispersion of polar polymers. Three molecular mechanisms determine roughly the relaxation spectrum of a high polymer: the reaction of the chain segments to the applied stress, the change of shape of the chain as a whole and the mutual interaction of chains. It is shown how the Boltzmann memory function and the spectrum may be obtained from creep data.

Testing

THE SOFTENING OF THERMOPLASTIC POLYMERS. R. F. Tuckett. Trans. Faraday Soc. *39*, 158–68 (June 1943). The general deformation produced in an amorphous high polymeric material by a given stress is analyzed into its 3 components which are termed ordinary elastic, highly elastic and viscous. These all have different dependencies on molecular size, structure, temperature and duration of stress. The effect of these variables is worked out and the information obtained is used to analyze the various empirical softening point tests which are in current use to characterize plastics. It is shown that such tests fall into 2 main groups: (1) those which measure the flow properties of materials and, as such, are of use in evaluating correct molding conditions; (2) those which essentially measure the temperature at which high elasticity develops, important in assessing heat distortion properties of the material under working conditions.

PLASTICS DIGEST

This digest includes each month the more important articles of interest to those who make or use plastics. Mail request for periodicals mentioned directly to publishers

General

NEW WINDSHIELD DEVELOPMENTS. A. L. Morse. S.A.E. Journal *51*, 289–93, 304 (Aug. 1943). The development of birdproof windshields was undertaken by the Civil Aeronautics Administration because of the number of pilot injuries resulting when conventional windshields were shattered by birds flying out in front of airplanes. This happens about twice a week. Various panel arrangements were tested to explore the effect of carcass weight, angle of impact, point of impact, panel temperature, method of support, and type of construction. The tests thus far conducted have indicated that the glass-vinyl resin type of laminated windshield with extended plastic edges bolted into an adequately reinforced windshield frame provides practically 100 percent protection for the DC-3 against collision with birds weighing up to 4 lb. and that a high degree of protection may be provided against collisions with birds weighing up to 20 pounds.

FPHA TO USE PLASTIC TUBING. Architectural Record *93*, 80, 94 (June 1943). Tubing made of polyvinylidene chloride has been accepted by FPHA for publicly financed war housing. 15,000 housing units will be equipped with plastic tubing in the preliminary program. The tubing is considered safe in a range of 200° F. and 100 lb./in.^{2} working pressure. Three sizes are being used: $^3/_8$ in., $^1/_2$ in. and $^3/_4$ inch. The wall thickness is 0.062 inch. The fittings are also made of this resin. Directions are given for installation. The results of experiments made in various laboratories are briefly described. It can be used safely for potable water supply without any toxic or injurious results.

SUBSTITUTES FOR SOLE LEATHER. W. Gallay. J. Am. Leather Chem. Assoc. *38*, 250–5 (July 1943). The advantages and disadvantages of leather for shoe soles are listed and the various substitutes for sole leather are discussed in terms of these points. The important substitutes are (1) the vinyl acetates, (2) the copolymers of vinyl chloride and vinyl acetate, and (3) ethyl cellulose specially plasticized by certain vegetable oils. The materials are used in the form of sheets, with or without fabric lamination. The one property of leather which has not been equalled with any substitute material is good permeability to air and to water vapor.

SEALING BY ELECTRONICS Modern Packaging *16*, 78, 110 (July 1943). Experimental equipment produced by the Radio Corp. of America employs radio frequency power to heat-seal packages. The material to be sealed is placed between the electrodes of the apparatus, which resembles a sewing machine, and the maximum heat is generated at the interface.

Materials

SOYBEAN-MODIFIED PHENOLIC PLASTICS. L. L. McKinney, R. Deanin, G. Babcock and A. K. Smith. Ind. Eng. Chem. *35*, 905–8 (Aug. 1943). The replacement of woodflour in phenolic plastics by soybean meal causes a rapid increase in flow while the addition of increasing amounts of soybean meal to constant ratios of phenolic resin and woodflour results in a gradual decrease in flow. These 2 effects can be balanced against each other to produce plastics having either higher flow or lower percentage of resin or both. The curing time increases with increasing content of thermoplastic soybean protein. This effect can be diminished in practice by longer periods of rolling the plastic before molding, use of paraformaldehyde accelerator, or preheating the molding powder. The water absorption of soybean-modified plastics is held within practical limits by a preliminary leaching and heat denaturation of the meal and by preparing the plastics by the wet mix instead of the dry mix method. The flexural strength varies slightly, and the impact strength decreases with increasing content of soybean meal; loss of impact strength is less for the wet method than for the dry method.

ACTIVE AND INACTIVE FILLERS IN POLYMERIC MATERIALS. K. Ueberreiter and G. Benkendorff. Kunststoffe *31*, 396–400 (1941). Volume-temperature curves were obtained for polystyrene, phenol-formaldehyde resins and glycerol phthalate resins with various fillers to determine the freezing points. Magnesium carbonate, chalk, litharge, zinc oxide and diatomaceous earth had no effect on the freezing points and are classed as inert fillers. Paper-mill sulfite waste liquor, woodflour and lamp black raise the freezing points. This indicates that a chemical reaction takes place between the resin and the filler. Resins of low molecular weight are absorbed. This reduces their plasticizing effect and raises the freezing point.

KEM-POL—PROPERTIES, CHARACTERISTICS AND APPLICATIONS. W. T. Walton. Rubber Age *53*, 234–9 (June 1943). The properties, characteristics and applications of a rubber-like vegetable oil polymer are given. Information on compounding is included.

Applications

ELECTRICAL APPLICATION OF NEW THERMOPLASTICS. T. S. Carswell and T. Alfrey. Elec. World *112*, 1951–3 (June 12, 1943). The electrical and physical properties and cost of cellulose triacetate, polyamides, polyethylene, polyisobutylene, butadiene-styrene copolymer, butadiene-acrylonitrile copolymer, benzylcellulose, styrene-chlorodiphenyl copolymer, chemically modified polystyrene, cross-linked polystyrene and organosilicon resins as well as those of 18 more common thermoplastic materials are discussed and tabulated.

PHENOLIC MATERIALS FOR WARTIME DEMANDS. F. W. Vogt. Paper Trade J. *117*, 28–30 (July 1, 1943). The use of laminated phenolic resin bearings in paper mill equipment is discussed. The design of several bearings is described and illustrated.

SARAN FILM—ITS PROPERTIES AND WARTIME USES. W. R. Dixon and H. L. Schaefer. Modern Packaging *16*, 72–3, 107–8 (July 1943). Saran film is ranked highest of all organic films in resistance to moisture transmission. Film 0.001-in. thick has an average moisture vapor transmission of 0.20 g. per 100 sq. in. per 24 hr.; the related value for film 0.002-in. thick is 0.16. Outdoor exposure does not impair strength or flexibility. It does not crack when folded at temperatures as low as −60° F. It is used in conjunction with a dehydrating agent to provide a moistureproof package for airplane engine parts, propellers, carburetors, fuel pumps, machine guns and hundreds of other items shipped all over the world for global warfare.

Coatings

CURRENT-CONDUCTING GRAPHITE PAINT. A. N. Novikov, T. A. Rensina and E. D. Filyanskaya. Vestnik Elektroprom. *12*, No. 4, 32–4 (1941). A current-conducting graphite paint consisting of an oil varnish, turpentine or hydrocarbon, and graphite was found to be superior to zinc coatings in serviceability, aging and application. The coating should contain 70 percent graphite.

HOW TO SELECT A CONCRETE FLOOR TREATMENT. C. S. Glickman. Chem. Ind. *52*, 740–1 (June 1943). The properties to be considered in the selection of a concrete floor treatment are 1) elasticity, 2) powdering, 3) crack filling, 4) slip resistance, 5) water resistance, 6) discoloration, 7) hardening, 8) ease of application, 9) drying time, 10) heat resistance, 11) inflammability, 12) color availability and 13) relative cost. Ordinary paints, varnishes and paraffin are not recommended.

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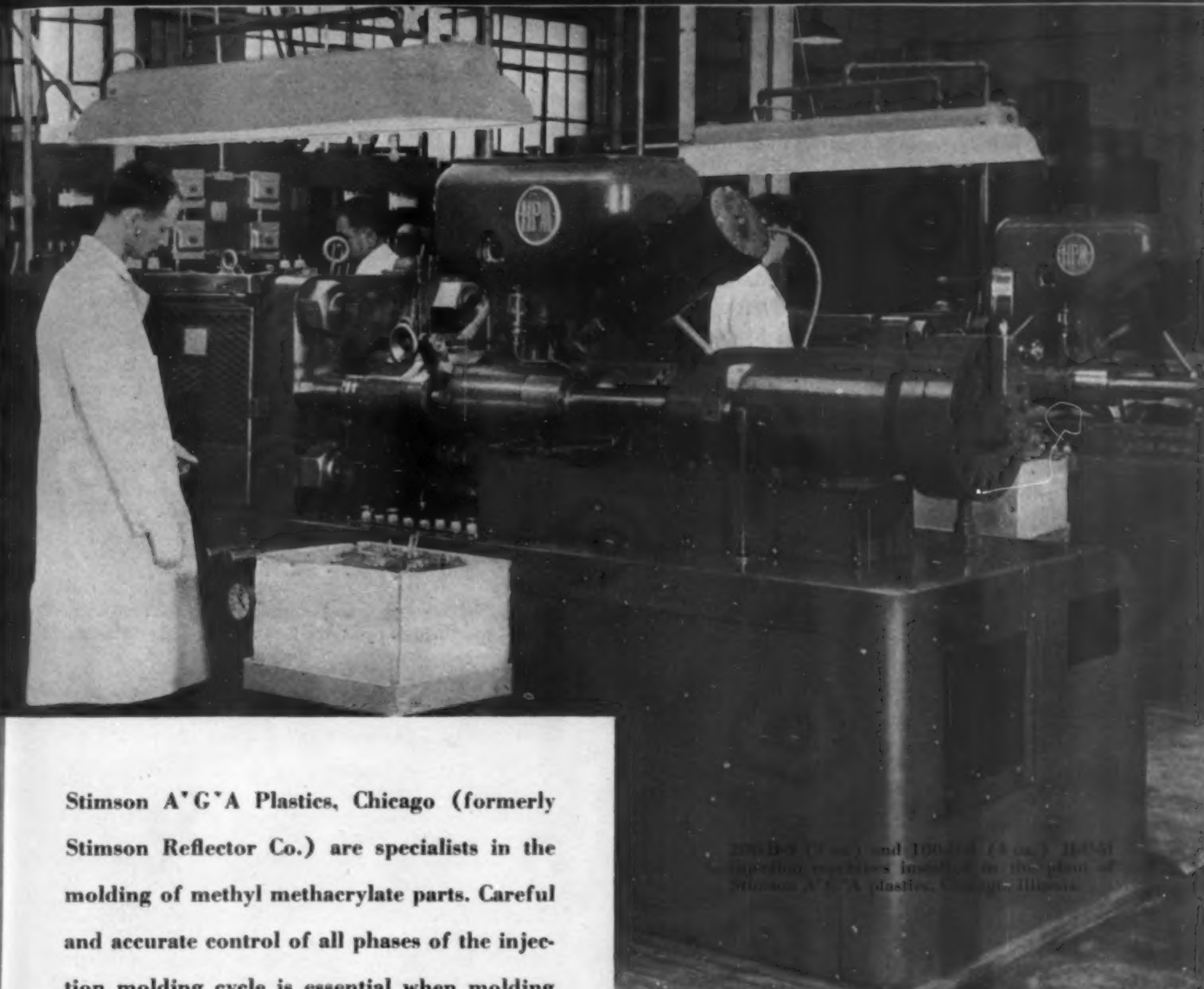

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U. S. Plastics Patents

Copies of these patents are available from the U. S. Patent Office, Washington, D. C., at 10 cents each

CONDENSATION PRODUCT. E. Korten (to General Aniline and Film Corp.). U. S. 2,321,493, June 8. A resin prepared by condensation of a phenolic hydroxy compound with furfuryl alcohol in the presence of a condensation catalyst.

NEW RESIN. G. F. D'Alelio (to General Electric Co.). U. S. 2,321,586, June 15. The reaction product of polymethylol melamine and a halogenated acetamide.

OIL SOLUBLE PHENOLIC RESIN. I. Rosenblum. U. S. 2,321,626, June 15. Phenol and formaldehyde are condensed in the presence of pine oil and an organo-zinc catalyst.

PHENOLIC RESIN. H. S. Rothrock (to E. I. du Pont de Nemours and Co., Inc.). U. S. 2,321,627, June 15. An aldehyde is reacted with bis-(hydroxyphenyl)-octadecane.

TREATMENT OF FILMS. G. B. Taylor (to E. I. du Pont de Nemours and Co., Inc.). U. S. 2,321,635, June 15. Films of polymers are cold drawn to permanent and substantial increase in length by passing through a drawing bath over rollers while under tension.

ACRYLIC INTERPOLYMERS. C. E. Barnes (to E. I. du Pont de Nemours and Co., Inc.). U. S. 2,321,728, June 15. An interpolymer of a methyl or ethyl ester of acrylic or methacrylic acid with a vinyl ester of acrylic or methacrylic acid.

RESINOUS COMPOSITION. I. W. Humphrey (to Hercules Powder Co.). U. S. 2,321,750, June 15. The product of the reaction of maleic anhydride and a polymerized terpene.

MOLDING COMPOUNDS. M. L. Macht and D. A. Fletcher (to E. I. du Pont de Nemours and Co., Inc.). U. S. 2,321,759, June 15. A molding compound composed of methyl methacrylate, styrene, vinyl acetate and methyl acrylate copolymerized.

PHENOLIC RESIN. F. M. Murdock (to Monsanto Chemical Co.). U. S. 2,321,766, June 16. The alkaline reaction product of phenol and formaldehyde is neutralized by addition of methyl phthalyl ethyl glycolate.

CAST PHENOLIC RESINS. C. S. Webber, S. B. Luce and F. M. Murdock (to Monsanto Chemical Co.). U. S. 2,321,-783, June 15. Phenol and formaldehyde are reacted in the presence of alkali, acidified, phthalyl glycolic acid is added, and finally a resin of the Novolak type is added.

p-CHLOROSTYRENE COPOLYMER. E. C. Britton and W. J. Le Fevre (to Dow Chemical Co.). U. S. 2,321,896, June 15. The copolymerization product of *p*-chlorostyrene and an unsaturated ether or ester containing at least 2 unsaturated linkages.

STYRENE COPOLYMER. E. C. Britton and G. H. Coleman (to Dow Chemical Co.). U. S. 2,321,897, June 15. A rubbery resin consisting of a copolymer of styrene and an aryloxylalkyl keto ester.

SYNTHETIC COATINGS. R. G. Quinn (to Johns-Manville Corp.). U. S. 2,321,937–8–9, June 15. Fiber board is coated by baking on a mixture of a thermosetting resin, a protein, a plasticizer and a paint in an aqueous dispersion or an aqueous dispersion of a thermosetting resin alone.

RESIN POLYMER. H. S. Rothrock (to E. I. du Pont de Nemours and Co., Inc.). U. S. 2,321,942, June 15. An unsaturated polycarboxylic acid ester is heated in the presence of a metallic drier and an acyclic monounsaturated monohydric alcohol.

CELLULOSE ETHER. C. B. Gilbert (to Hercules Powder Co.). U. S. 2,322,013, June 15. Ethyl cellulose plasticized with a mixture of plasticizers consisting of at least one-third acetyl triethyl citrate.

NON-TACKY ADHESIVE SHEETING. G. F. Nadeau and C. B. Starck (to Eastman Kodak Co.). U. S. 2,322,048, June 15. A non-tacky sheet material, capable of being joined to a surface by addition of heat, consisting of cellulose acetate base coated with vinyl resin and a cellulose ester containing a plasticizer.

OLEFINIC INTERPOLYMERS. R. M. Thomas, I. E. Lightbown and W. J. Sparks (to Jasco Inc.). U. S. 2,322,072–3, June 15. An isoolefin is polymerized with a conjugated diolefin in contact with a Friedel-Crafts catalyst at $-50°$ C. to $-150°$ C., the high molecular weight polymers are separated, compounded with sulfur and sulfur compounds and finally cured with the aid of heat.

ROSIN BASE RESIN. F. G. Oswald (to Hercules Powder Co.). U. S. 2,322,197, June 15. A resin composed of pentaerythritol, a rosin acid and an alpha-beta unsaturated polybasic acid.

PLASTICIZER. E. L. Kropa (to American Cyanamid Co.). U. S. 2,322,240, June 22. A urea-formaldehyde resin plasticized with the reaction product of a polyamine with a hydroxy-carboxylic acid having at least 8 carbon atoms.

VINYL HALIDE POLYMERS. L. B. Morgan and W. M. Morgan (to Imperial Chemical Industries, Ltd.). U. S. 2,322,309, June 22. Flocculose polymers of vinyl halides are prepared by agitating the halide in an aqueous solution of polymeric acrylic or methacrylic acids and interpolymers of at least one of these acids with an ester of one.

RESIN WINDSHIELD. I. E. Muskat, M. A. Pollack, F. Strain and W. A. Franta (to Pittsburgh Plate Glass Co.). U. S. 2,322,310, June 22. An artificial glass consisting of an ester of acrylic or alpha substituted acrylic acid, surfaced with a film of a polymer of an organic compound having 2 unsaturated polymerizable groups separated by oxygen linkages.

ROSIN POLYMERS. A. L. Rummelsburg (to Hercules Powder Co.). U. S. 2,322,316, June 22. Polymerized rosin and its esters are refined by dissolving the material in an organic solvent with a polymerization catalyst, separating catalyst after the reaction is completed by washing with water, removing the water and removing last traces of impurities with an adsorbent.

RESINOUS COATING. D. G. Patterson (to American Cyanamid Co.). U. S. 2,322,542, June 22. Linoleum coating composed of a non-conjugated terpene hydrocarbon, a polyhydric alcohol and maleic or fumaric acid heated in the presence of *p*-toluene sulfonic acid and to which are added linseed oil acids.

AMINOPLAST RESINS. G. F. D'Alelio (to General Electric Co.). U. S. 2,322,566–7, June 22. Heat curable amino-

plasts are cured by addition of oxanilic acid and are reacted with compounds consisting of an aryl nucleus attached by means of a sulfur atom to a substituted morpholine tetrahydro-*p*-isoxazine.

MODIFIED VINYL RESIN. B. J. Dennison (to Pittsburgh Plate Glass Co.). U. S. 2,322,571, June 22. A modified vinyl composition comprising a polyvinyl acetal and a glyceryl alpha, gamma dialkyl ether.

CELLULOSE MIXED ESTERS. J. W. Hill (to E. I. du Pont de Nemours and Co., Inc.). U. S. 2,322,575, June 22. A process comprising the reaction of cellulose with a saturated aliphatic aldehyde, an esterifying reagent, comprising an unsubstituted aliphatic monocarboxylic acid and the anhydride of a different acid of the same type.

CELLULAR BODIES. W. O. Lytle (to Pittsburgh Plate Glass Co.). U. S. 2,322,581, June 22. Heat-resistant cellular masses are prepared by dropping a mixture of a heat-resistant thermoplastic material and an agent decomposable by heat to a gas through a heated chamber so that the decomposition of the agent forms a cellular mass.

LAMINATED GLASS. H. R. Marini (to Pittsburgh Plate Glass Co.). U. S. 2,322,582, June 22. A sheet of mesh material having its central portion open to form a frame, a plastic innerlayer in which the mesh is buried, and glass plates adhered to the innerlayer.

RESINOUS POLYMER. W. J. Sparks and D. C. Field (to Standard Oil Development Co.). U. S. 2,322,670, June 22. Resin prepared by reacting an aromatic chloride with a tertiary alkyl halide in the presence of aluminum chloride.

RUBBERIZED TEXTILE. W. S. Gocher and A. J. Jennings (to E. I. du Pont de Nemours and Co., Inc.). U. S. 2,322,-779, June 29. Rubber-coated fabric having on the surface a flexible film comprising a mixture of a synthetic polyamide and a phenol-aldehyde resin.

HALOGENO-HYDROCARBON RESIN. V. Molinari (to Bakelite Corp.). U. S. 2,322,870, June 29. Resin formed by condensing, in absence of water, a halogen-substituted aromatic hydrocarbon or ether with an aldehyde in the presence of sulfuric acid or aromatic sulfonic acid.

ADHESIVE. S. G. Saunders and H. Morrison (to Chrysler Corp.). U. S. 2,322,886, June 29. Adhesive comprising a liquid vehicle and a suspension of asphalt, and a copolymer of a diolefin and rubber.

TREATMENT OF PAPER. G. L. Schwartz and J. F. Walker (to E. I. du Pont de Nemours and Co., Inc.). U. S. 2,322,887–8, June 29. A paper web is treated with an aqueous starch dispersion, a methylolmelamine, a polyvinyl alcohol and an ammonium salt, and heat cured.

STABILIZATION OF POLYMERS. J. B. Howard (to Bell Telephone Laboratories, Inc.). U. S. 2,322,938, June 29. A linear polyester with ester linkages, having hydroxyl groups on the ends of the molecules and having a high molecular weight, is prevented from undergoing degradation by oxidation by the presence of a non-alkaline antioxidant.

COATED FABRIC. F. T. Peters (to E. I. du Pont de Nemours and Co., Inc.). U. S. 2,322,953, June 29. A fabric coated with a thin polyamide and a continuous cellulose derivative coating.

POLYVINYL ALCOHOL THREAD. H. P. Schmitz (to Alien Property Custodian). U. S. 2,322,976, June 29. A solution of polyvinyl alcohol is cast in the form of a thread through a nozzle upon a rotating drum where it is dried and then removed.

MODIFIED UREA-FORMALDEHYDE RESIN. E. F. Siegel (to Reichhold Chemicals, Inc.). U. S. 2,322,979, June 29. A resin is produced by reacting urea and formaldehyde, at a pH of 8–10 and a temperature of 60–90° C., in aqueous solution, dehydrating and finally reacting the condensation product with a monohydric alcohol at a pH of 5–6.

CELLULOSE PRODUCT. L. Ubbelohde (to Alien Property Custodian). U. S. 2,322,981, June 29. An aqueous cellulosic solution and a solution of urea and formaldehyde are mixed, dried and the urea-formaldehyde resin set within the cellulose material.

CONDENSATION PRODUCTS. A. Wolfram and H. Jahn (to Alien Property Custodian). U. S. 2,322,990, June 29. Formaldehyde is reacted, in the presence of condensation catalysts, with the condensation product of an hydroxy-benzene and an aliphatic polymer of acetylene.

POLYAMINE-ACID IMIDE CONDENSATE. H. Kroeper (to Alien Property Custodian). U. S. 2,323,054, June 29. A cyclic imide of a dicarboxylic acid is condensed with an amine containing at least 2 amino groups.

PLYWOOD ASSEMBLY. A. R. Welch. U. S. 2,323,105, June 29. Method for preparing plywood consisting of glue-coated core plies and uncoated face plies in a continuously moving assembly line.

FLOOR COVERING. S. Caplan (to Harvel Corp.). U. S. 2,323,118, June 29. A thermoplastic floor covering is prepared from a mixture of cashew nut shell liquid, an aldehyde, an alkaline catalyst, a cumar resin, rosin and Congo gum, reacted by heat.

CASHEW NUT RESINS. M. T. Harvey (to Harvel Corp.). U. S. 2,323, 130, June 29. Organic polymerizates of cashew nut shell liquid are reacted with chloroprene and hexamethylenetetramine.

RUBBER HYDROHALIDES. T. M. Andrews and H. F. Reeves, Jr. (to Bay Chemical Co., Inc.). U. S. 2,323,185, June 29. Rubber is treated, in a solution of butyl alcohol, with hydrohalogen acids.

CURING DEVICE. C. E. Bennett (to Okonite Co.). U. S. 2,323,191, June 29. Electrical conductors are coated with heat-curable resins by passing through a chamber where it is coated, placed under pressure and the coating is cured by means of a high frequency electrostatic field.

INSULATOR COMPOSITION. H. J. Kauth (to General Cable Corp.). U. S. 2,323,333–4, July 6. A drying oil-modified alkyd resin in combination with a furfuryl alcohol polymer is baked onto wires; a composition of a furan resin, a flexibilizing agent, and a polyamide is used as enamel for wires.

UREA-FORMALDEHYDE RESIN. I. Rosenblum. U. S. 2,323,357, July 6. Urea and formaldehyde are reacted in the presence of alcohol until a hydrophobic polymer is formed which will form stable mixtures with modified alkyd resins.

MOLDING COMPOSITION. G. W. Whitehead (to Monsanto Chemical Co.). U. S. 2,323,363, July 6. A polyvinyl acetal resin to which is added a monohydroxy carboxylic acid in order to prevent sticking to a mold.

PLASTIC MATERIALS. H. Dreyfus (to Celanese Corp. of America). U. S. 2,323,383, July 6. A molten superpolymer is extruded and passed into an inert medium at high temperature and then into a similar medium at a lower temperature where the molded article is cooled.

PLASTIC MOLDING. F. P. Stull. U. S. 2,323,577, July 6. Device for molding a plastic article from a bar of material.

MODIFIED ALKYD RESINS. G. F. D'Alelio (to General Electric Co.). U. S. 2,323,706, July 6. A polymerizable composition consisting of a polyester of a polycarboxylic acid with a 3-hydroxy alkene-1 and an unsaturated alkyd resin.

PLASTIC STRIPS. O. S. Zimmerman and T. J. Tully (to Plastex Trim Corp.). U. S. 2,323,862, July 6. Strip material is

produced by passing plastic material into a forming compartment where it is sufficiently heated to be deformable under pressure exerted by shaping rolls, after which shaping it is cooled.

UREA RESIN. G. F. D'Alelio (to General Electric Co.). U. S. 2,323,898, July 13. An alcohol-modified condensation product of ingredients comprising a urea, an aliphatic aldehyde and a halogenated acetone.

INSULATING MATERIAL. D. Roberts (to Rubatex Products, Inc.). U. S. 2,323,936, July 13. An insulating material comprising a closed cell gas expanded mixture of rubber and a phenol-formaldehyde condensation product.

ADHESIVE. C. J. Malm and G. D. Hiatt (to Eastman Kodak Co.). U. S. 2,324,097, July 13. An adhesive sheet comprising a capric acid ester of cellulose.

DIPPING LACQUER. C. J. Malm and G. J. Clarke (to Eastman Kodak Co.). U. S. 2,324,098, July 13. A lacquer, comprising a cellulose organic acid ester dissolved in toluene, capable of gelation while containing all the solvent when cooled to 10° to 50° C.

RUBBER HYDROCHLORIDE. J. P. Chittum and G. E. Hulse (to U. S. Rubber Co.). U. S. 2,324,278, July 13. A pellicle comprising rubber hydrochloride and a substituted piperazine which serves as a light stabilizer.

PLASTIC BAGS. J. Hohl, O. Bjering, E. E. Lakso and C. W. Vogt (to Owens-Illinois Glass Co.). U. S. 2,324,393, July 13. Apparatus for forming bags by folding, cutting and cementing a continuously moving film of plastic material.

COOLING OF MOLDED ARTICLES. D. R. Hull (to E. I. du Pont de Nemours and Co., Inc.). U. S. 2,324,397, July 13. Extruded article is passed into a continuously flowing body of cooling liquid.

HELMET. E. E. Destrike. U. S. 2,324,420, July 13. Scalp treating helmet is formed by applying tight fitting cap to head and applying to this a quick-setting resin which may be removed from the cap and then coated with a second layer of resin.

ABRASIVES. N. P. Robie (to U. S. Carborundum Co.) U. S. 2,324,426-7, July 13. Abrasive grains are embedded in binders comprising a neutralization product of an alkali with a partial polyvinyl ester of a polybasic acid or with a heteropolymer of an olefinic acid and a compound containing the vinyl group.

SYNTHETIC RESIN. P. Castan. U. S. 2,324,483, July 20. A polybasic carboxylic acid anhydride is condensed with the reaction product of a phenol having at least 2 hydroxy groups and an epichlorohydrin.

SIZING. E. W. Spanagel (to E. I. du Pont de Nemours and Co., Inc.). U. S. 2,324,601, July 20. A sizing for yarn comprising an aqueous solution of a hydroxylated polyvinyl resin and 5 to 25 percent of boric acid based on the weight of the resin.

ENAMEL COATING. W. N. Stoops and W. A. Denison (to Carbide and Carbon Chemicals Corp.). U. S. 2,324,739-40, July 20. A coating composed of an acid-reacting vinyl resin heat-treated with a polyalkylene glycol; a stabilized solution of a copolymer of a vinyl compound such as styrene, vinyl acetate or vinyl chloride with maleic acid, or a polyalkylene glycol.

MODIFIED PHENOLIC RESIN. C. W. Bowden, Jr. (to Hercules Powder Co.). U. S. 2,324,758, July 20. A molding resin comprising the reaction products of a phenol and an aldehyde and extracted pine wood pitch.

FILTER MATERIAL. W. Harz, K. Neuss, H. Rein, E. Hubert and C. Kayser (to Alien Property Custodian). U. S. 2,324,838, July 20. A filter comprising a fabric consisting of filaments of polyvinyl resins heated to a temperature sufficient to adjust the porosity thereof.

MIXED POLYMERS. W. Zerweck and W. Kunze (to General Aniline and Film Corp.). U. S. 2,324,896, July 20. A vinyl sulfamide is copolymerized with a different polymerizable vinyl compound.

METHACRYLATE POLYMERS. C. T. Kautter and E. Trommsdorff (to Rohm and Haas Co.). U. S. 2,324,935, July 20. Methacrylic acid esters, nitrile and anhydride polymers are polymerized in the presence of a chlorinated unsaturated compound such as allyl chloride, 2-methallyl chloride, sym-dichloroethylene, trichloroethylene, 1,2-dichloropropylene, etc.

POLYAMINE RESINS. H. Kroeper and H. Haussmann (to Alien Property Custodian). U. S. 2,324,936, July 20. A mononitrile containing a carboxylic acid group is reacted with an amine having at least one amino hydrogen atom.

MOLDING METHOD. W. Q. Lohrand and C. H. Whitlock (to Firestone Tire and Rubber Co.). U. S. 2,324,978, July 20. A reinforcing member is molded into a plastic article.

NONSHRINKING YARN. H. G. Ingersoll (to E. I. du Pont de Nemours and Co., Inc.). U. S. 2,325,060, July 27. The shrinkage temperature of oriented ethylene polymer yarns is raised by heat treating while under stress sufficient to prevent retraction.

BOTTLE CAP. H. G. Vore (to American Seal-Kap Corp.). U. S. 2,325,086, July 27. A bottle cap with a thermoplastic coating is heated on a bottle with a device which provides sufficient heat to effect sealing without overheating.

ADHESIVE. H. A. Bruson and J. L. Rainey (to Resinous Products and Chemical Co.). U. S. 2,325,105, July 27. An adhesive comprising a solution of a bisthioammeline ether-formaldehyde resin, an acidic condensation catalyst and soluble blood.

STRAIN DETERMINATION. G. Ellis (to Magnaflux Corp.). U. S. 2,325,116, July 27. Distribution of elastic strains in a body is determined by applying a film-forming composition, including a brittle resin, to its surface and subjecting this film to increasing loads until cracks are formed, these loads being inversely proportional to the relative strain concentrations in the body.

STRIP MATERIAL. C. W. Leguillon and E. A. Davis (to B. F. Goodrich Co.). U. S. 2,325,139, July 27. In the formation of strips of plastic materials a supporting form accompanies the strips in the production assembly.

SANDPAPER. J. M. Borglin (to Hercules Powder Co.). U. S. 2,325,172, July 27. Abrasive consisting of a backing of cellulosic sheet, to which abrasive grains are attached by means of an adhesive comprised of polymerized rosin, water soluble salts thereof, and a proteinaceous material.

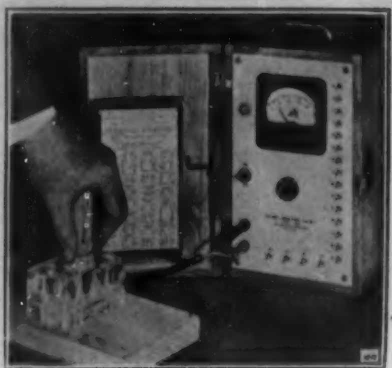
POLYVINYL ACETAL RESIN. E. R. Derby (to Monsanto Chemical Co.). U. S. 2,325,177-8, July 27. Polyvinyl acetal resin is plasticized with a mixture of dilauryl phthalate and a substance such as diethylene glycol and also with a mixture of phenyl ethyl alcohol and a substance such as dibutyl diglycolate.

PROTEIN PLASTIC. S. Pellerano (to George Morrell Corp.). U. S. 2,325,272, July 27. Articles of protein such as casein, soy bean, etc., are soaked in a solution of a zinc salt in water, then immersed in formaldehyde solution until hardened.

TREATED PAPER. K. W. Britt (to Scott Paper Co.). U. S. 2,325,302, July 27. A high-wet-strength paper containing a cured urea-aldehyde resin.

AMINOPLAST RESINS. G. F. D'Alelio (to General Electric Co.). U. S. 2,325,375-6, July 27. A heat curable aminoplast obtained by reacting an amidogen and an aliphatic aldehyde and modified with a malonic ester. Reaction product of simultaneous partial condensation of an amidogen, formaldehyde and a keto ester.

MACHINERY and EQUIPMENT



★ THE KAYDEL MOISTURE GAGE AND PRESSURE contactor manufactured by Hart Moisture Gauges, Inc., New York City, is said to determine quickly the moisture content of plywood, veneer, paper, Cellophane, plastic and other organic substances without surface marring. The contactor (above) is a small block of transparent plastic topped by a handle and equipped with electrodes on its underside. When the contactor is pressed against a surface, the material's resistance to the passage of a small electrical current is indicated on the dial. The contactor then is lifted and touched to a series of studs on the instrument panel. Percentage of moisture is shown by a marking on the particular stud that gives the same dial reading as the material itself. The entire outfit weighs less than 8 lbs. and operates by dry batteries.

★ A NEW DRIVE WHEEL MOVEMENT VISE RECOMMENDED for grinders, drill presses and other machine tools has been introduced by Berco Mfg. Co., Chicago, Ill. Features are said to include a drive wheel motion which gives $2^3/_4$ in. lateral clearance, double swivel construction which permits any conceivable horizontal position, right-angle clearance which allows perpendicular position without base obstruction, and positive horizontal setting for highest 180° accuracy.

★ RECOMMENDED FOR DEBURRING EXTERIOR edges and finishing irregular surfaces ordinarily hard to get at, a new line of abrasive wheels and points has been introduced by Flex-Abrasive Co., Chicago, Ill. These units are so constructed that a fresh abrasive surface constantly is in contact with the work. Made in a variety of types and sizes for use on alloy steels, wood, rubber, resin and plastics, these wheels and points are said to be easy to remove without use of tools, nuts or split shafts.

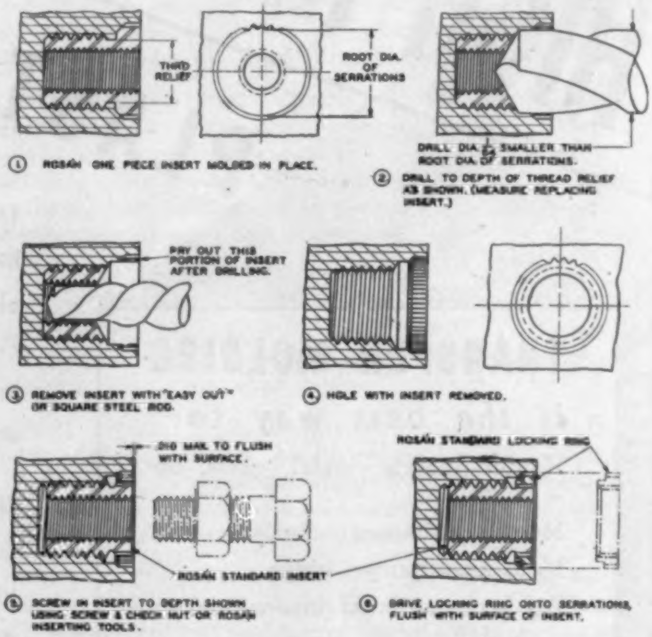
★ A METAL CUTTING BANDSAW SAID TO EMPLOY A new gravity feed principal by which the saw feeds into work through movement of a balanced blade wheel frame, has been introduced by Universal Vise & Tool Co., Parma, Mich. Blade pressure automatically is regulated by the texture and hardness of the metal being cut thus eliminating blade breakage from incorrect pressure. Adaptable for cut off, trim and contour work, these bandsaws are available with saws $^1/_4$, $^1/_2$ and $^3/_4$ in. wide. and with speeds of 81, 161 and 264 ft. per minute.

★ A 2-POSITION, 2-POLE INTER-COMMUNICATION switch in either a Bakelite or Tenite case is being manufactured by Trav-Ler Karenola Radio and Television Corp., Chicago, Ill. Contact springs are held to close tolerance, and the entire assembly has been tested to withstand more than 100,000 operations. The switch is used extensively in aircraft, tanks and other military equipment.

★ A RHEOSTAT POTENTIOMETER DESIGNED ESPECIALLY for low resistance, low wattage applications by Ohmite Manufacturing Co., Chicago, Ill., is finding a place in the instrument field. Provided with 3 terminals so that it can be used as a potentiometer or voltage divider, the unit can be supplied a maximum resistance of about 1 ohm and a minimum total resistance of approximately 0.1 ohm. Shafts for knob or for screw driver control can be furnished with the piece.

★ A NEW ELECTRONIC SEARCHRAY DESCRIBED AS A compact X-ray unit which can be operated safely by unskilled personnel for inspection work, has been announced by North American Philips Co., Inc., Dobbs Ferry, N. Y. Providing a non-destructive means for internal inspection of small parts and molds of ceramics, plastics and light alloys, and of packaged food, assemblies, etc., the machine is both fluoroscopic and radiographic in action. After the unit is plugged into any 110-volt power supply, the object is placed in the compartment, the door closed and a button pressed. The object immediately is seen fluoroscopically through an eye-level eye piece. The machine takes up less than 5 sq. ft. of floor space and weighs 425 pounds.

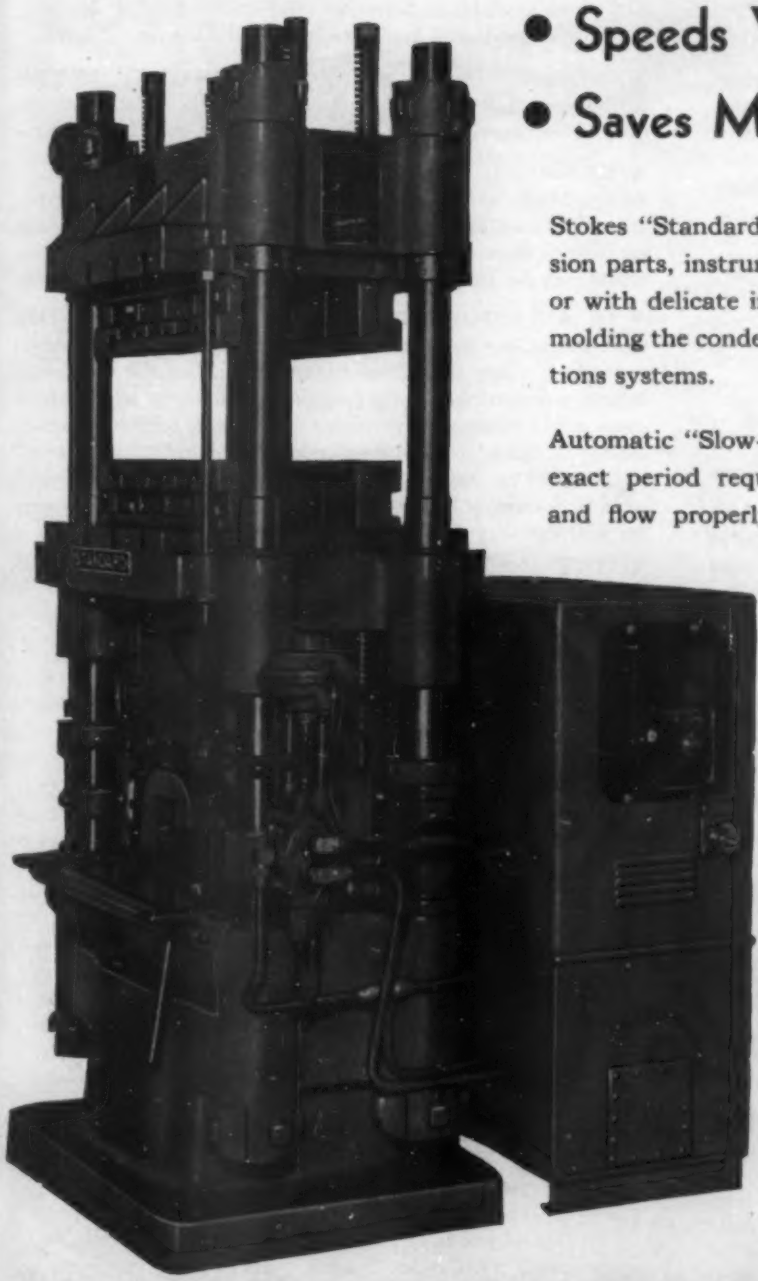
★ ANKER-HOLTH MANUFACTURING CO. HAS DEveloped a supercharged combination high and low pressure oil hydraulic power unit designed to meet the needs of a hi-power hydraulic unit developing pressure in the 3000-lb. range. The pump and $^1/_2$-hp. motor are mounted directly on the oil reservoir while the low-pressure bypass control is built into the pump body. Both high and low pressure can be controlled individually on the power lines or through automatic control.



★ A NEW APPLICATION OF THE ROSAN LOCKING system designed to permit threaded inserts and studs in metals, plastics and other materials to be locked in but later removed without injury to the material, has been announced by Bardwell and McAllister, Inc., Hollywood, Calif. This design is said to allow a standard threaded insert or stud to be screwed and locked in after the new one-piece molded-in insert is withdrawn. To effect the removal, the top of the insert is drilled until the drill passes into the thread relief. This leaves the outer portion of the head in the form of a serrated ring, and an "easy out" tool inserted in the hole backs out the threaded portion. The remainder of the ring may be lifted by hand. The procedure for removing the stud is the same except a hollow mill is used for drilling out the locking flange. Threads and serrations are left molded in the material. The diagram above shows the step-by-step application of this Rosan locking system.

"SLOW-CLOSE" *Proves* ITS VALUE in Molding Condensers

- Reduces Rejects to a Minimum
- Assures Uniform Dielectric Strength
- Speeds War-Time Production
- Saves Material, Labor, Mold Wear



Stokes "Standard" Presses are ideal equipment for molding precision parts, instrument housings, parts with thick and thin sections or with delicate inserts, etc. . . . they are preferred equipment for molding the condensers used in radio and other types of communications systems.

Automatic "Slow-Close" times the final closing of the mold to the exact period required for the material to plasticize completely and flow properly. The action repeats, automatically, exactly, indefinitely. It eliminates human error, produces moldings of closest uniformity, with very few rejects. Together with Automatic Cycle Control it enables unskilled labor to do the finest precision work, enables one operator to run several presses, affords more heats and produces more parts per hour.

Improved Stokes "Standard" Presses are proving their advantages in war work of many kinds. These advantages will prove of equal value in the post-war economy. For more information write for new Catalog No. 427.

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F.J.Stokes MOLDING EQUIPMENT

FJS Est. 1895

PUBLICATIONS

Write directly to the publishers for these booklets. Unless otherwise specified, they will be mailed without charge to executives who request them on business stationery. Other books will be sent postpaid at the publishers' advertised prices

Mechanical Drawing

by Ervin Kenison and James McKinney. Revised by Tom C. Plumridge

Industrial Div., American Technical Society, 850 East 58th St., Chicago, Ill., 1943

Price: $2.00 **330 pages, illustrated**

How to attain the skills and technical knowledge needed by a draftsman to interpret specifications properly is simply and clearly explained in this textbook, which covers the rudiments of mechanical drawing. Beginning with instructions on the selection of instruments and materials, it continues in detail through the completion of working drawings with emphasis on the principles of projection. Drill work is given in the use of instruments, and practice problems are presented to show the student how to become adept in making neat, accurate drawings.

Substitutes

by H. Bennett

Chemical Publishing Co., Inc., 234 King St., Brooklyn, N. Y., 1943

Price $4.00 **225 pages**

Recognizing that a substitute may be excellent in one instance and worthless in another, the author has compiled herein a list of substitutes for chemicals, metals, fibers and other commercial products, which offers a starting point for further research by the expert. The list is made from a file of personal experiences with numerous products over a period of sixteen years, supplemented by information from other sources. A section on substitute requirements is included and miscellaneous problems which should be taken into consideration before final selection of a substitute is made.

★ CONTINENTAL-DIAMOND FIBRE CO., NEWARK, Del., has issued 3 booklets, one discussing Dilecto, a laminated phenolic plastic; one dealing with vulcanized fibre; and a third listing 7 non-metallic materials of the company. Catalog DO 43 which deals with Dilecto describes in detail the various uses of this plastic, the grades of sheet available and methods of machining. One of the numerous tables in this catalog gives NEMA grades and approximate equivalent U. S. Government grades. Catalog DF 43 emphasizes with pictures the methods by which Diamond vulcanized fibre can be fabricated in the shop and presents in tabular form the specific properties of the fibre. The third booklet in addition to describing the company's vulcanized fibre, Dilecto, Dilectene, Celoron, Micabond, Vulcoid and Haveg-Saran, lists their specific properties in tabular form.

★ ROHM & HAAS CO., PHILADELPHIA, PA., HAS ISSUED a small book dealing with the mechanical properties of Plexiglas. Second of a series of technical booklets covering the optical, mechanical, thermal, chemical and electrical properties of Plexiglas, the information was written for the benefit of engineers and designers. Numerous charts are used to illustrate the properties of this plastic and test methods are described in detail.

★ FACED WITH TEMPORARY SUSPENSION OF THE National Paint Dictionary because of wartime restrictions and shortages, yet desirous of keeping these books up to date, Stewart Research Laboratory, Washington, D. C., has printed supplementary listings in the National Paint Bulletin. These listings may be clipped out and inserted in the space provided at the end of the present Dictionary. A charge of $3 is made for Series I of the Addenda which brings the reference volume up to date as of July 1, 1943.

★ A RADIO DATA HANDBOOK CONTAINING FORMULas, charts and data most commonly used in the radio and electronics field has been published by Allied Radio Corp., Chicago, Ill. Divided into 4 parts: mathematical data, radio and electronic formulas, engineering and servicing information, and 4-place log. and trig. tables, the book is designed for easy reference. Diagrams are used throughout to illustrate the formulas and explain the text. The handbook is priced at 25 cents.

★ A WELL-ILLUSTRATED 12-PAGE BOOKLET ISSUED by South Bend Lathe Works, South Bend, Ind., presents the lathes now available in Series 900 and 1000. All specifications, capacities, speeds and feeds are tabulated for easy reference.

★ "90 YEARS OF INDUSTRIAL PIONEERING" IS THE title of an attractive booklet brought out by Swan-Finch Oil Corp., New York, N. Y., to commemorate its 90th anniversary.

★ HAMMOND MACHINERY BUILDERS, INC., KALAmazoo, Mich., have a new bulletin, No. 502, illustrating cylindrical grinding, polishing and buffing machines. Photographs are used to show the many uses to which the standard machine model may be put through the use of accessories and fixtures.

★ IN AN EFFORT TO REDUCE ABSENTEEISM, THE Government has issued two bulletins, one describing the correct method of weight-lifting, the other advising on the most satisfactory procedure for selecting women for industrial jobs. Physicians, safety experts and personnel officers were consulted in compiling "A Guide to the Elimination of Weight-lifting Injuries," copies of which may be obtained from Division of Labor Standards, U. S. Dept. of Labor, Washington, D. C. "Choosing Women for War-Industry Jobs," advises job analysis as the first step in placement, followed by careful matching of the individual and her peculiar characteristics to the position. Copies may be obtained at a cost of 5 cents from Superintendent of Documents, Government Printing Office, Washington.

★ A NEW BOOKLET HAS BEEN ISSUED BY HERCULES Powder Co., Wilmington, Del., discussing properties and uses of Dresinates (water soluble resinates) in soluble oils. Several paragraphs are devoted to directions for preparing a typical emulsion. Another pamphlet issued by the Synthetics Dept. of the same company supplements a discussion of the properties of hydro-abietyl alcohol with a detailed table. The last 2 pages of this booklet treat of uses of this alcohol derived from rosin.

"Representative Cost Finding Systems in the Plastics Industry," second in a series of articles for distribution exclusively within the industry, has been prepared by George S. May Business Foundation in cooperation with the companies mentioned in the booklet, and published by MODERN PLASTICS. Cost finding systems are discussed as they are applied at Imperial Molded Products Corp., Mack Molding Co., Booton Molding Co. and Tech-Art Plastics Co. Copies may be obtained from the magazine at a cost of two dollars.

"In-Process Factory Cost Accounting," second article on this subject to be published by MODERN PLASTICS, was prepared by Harold J. Luth. This booklet presents a third method—in-process costing accounting—as against the traditional job-cost method of accounting or the standard-cost system. In this system, costs are controlled while articles are in process of manufacture. The method is based on a comparison of actual cost at the end of a 30-day period with anticipated cost.

WASHINGTON ROUND-UP

Current news, Government orders and regulations affecting the plastics industry, with analysis of the plastics situation

There is scarcely a subject confronting the plastics industry today that is of more importance than that of applying plastics to the right purpose. Far-seeing industry leaders are aware of the great dangers (multiplied many-fold by the war emergency) involved in the inflated manufacture of items in plastics that will go back to metal or some other material after the war. They are constantly urging that all use of plastics as a mere substitute material be discontinued. There are plenty of applications today where plastics can do a better job than any other material. Those jobs and those jobs only should be done in plastics.

As an articulate champion of that cause, MODERN PLASTICS *presents James H. Savage, plastics consultant in WPB's Conservation Division. He has spent practically a lifetime in plastics development. He has seen all the fads, gimcracks and gadgets come and go. In his present position, he has had unusual opportunities to see how and where plastics can best be applied. We are pleased to present his views on plastics conservation and urge careful consideration of his recommendations.*—ED.

CONSERVATION PROGRAM FOR THE PLASTICS INDUSTRY

by JAMES H. SAVAGE*

Plastic materials used only in their true plastic applications are performing a duty as patriotic as that of any marine on the fighting front. But plastic materials wasted in misapplications are actually hampering the war effort. These misapplications produce unnecessary scarcities, with the result that engineers often lay aside the development of some vitally needed plastic item or component simply because they find a shortage of one of the materials involved. In far too many cases this shortage was produced by the diversion of a plastic material to some purpose which another material, not necessarily plastic, and not so critically needed or limited, might have served just as well or better. The forestalling and solution of such problems is one of the industry's most urgent tasks today.

This unfortunate situation has come about largely because of the accelerated growth of the plastics industry under wartime conditions. As metals were progressively absorbed into the production of armaments, the manufacture of commonplace articles from steel and aluminum became a thing of the past. Other materials had to be used or the items would disappear from the market.

Plastics inventions and applications kept pace with the necessity for metal substitutes, and while those in our war industry did not always know what to do with this new family of materials, they seized upon it with interest. Plastics were hailed as a cure-all for industrial shortages. As this trend approached its climax, inquiries poured in to the industry concerning the uses of plastics for license plates, truck bodies and heavy railroad equipment, and it was even suggested that they might be used for internal combustion engines. Only after costly mistakes had been made was the fact acknowledged that the plastics industry must do its thinking in terms of grams and pounds rather than in tons. When plastics were considered as possible substitutes for large tonnage materials, their very nature had been disregarded. A plastic tool box for a tank or truck would not save enough steel to affect the metal picture, but it would expend a plastic material needed for more suitable work.

Another point which both consumer and producer needed to remember is that each plastic has its particular uses. Just as nails are not made from carbon steel nor molds from Bessemer, so aircraft glazing cannot be produced from high impact thermosetting material nor M-52 fuzes from a thermoplastic. A possible example is the disaster equipment of evacuation gear. If a kit is opened and a necessary article found to be missing, valuable time has been lost and a man may die. However, if the kit could be made all or partly of transparent plastic material, its contents would be instantaneously visible. A plastic will do this job—a job which is vitally important and which could be done by no other material.

Substitution for substitution's sake is not conservation. It must be based on sound engineering. Frequently the consideration of such a problem brings about a redesign which definitely improves the product. An outstanding case is that of the battery box in which polystyrene takes the place of rubber and thereby brings about improved performance. The same advantages have been achieved through the replacement of duralumin by a phenolic laminate in speaker diaphragms. By reducing the total weight and increasing battle vision, the plastic glazing in our fighting planes and bombers conserves fuel, extends the operating range, and increases the value of the plane as a military weapon.

It is well, in considering any plastic item, to balance the factors of man and machine hours and tool room time involved in its fabrication against those required for the production of that item from another material. Thus, the plastic M-52 fuze formerly machined from aluminum not only conserves a critical metal but it also saves precious time in manufacture. On the other hand, to duplicate molds known to be in existence merely for the sake of getting a job would be very poor conservation, since it would not only waste steel but also tool room hours, and probably also delay the completion of some truly essential mold.

Wisely expended, there should be enough of the necessary materials to take care of all of our military and essential civilian requirements. In order to play its part intelligently and efficiently in this undertaking, the plastics industry might well adopt the following conservation measures:

1. Refuse to use plastic materials in any but sound applications.
2. Refuse to accept the job where, although the plastic material might do almost as well as some other material, its use would completely disrupt the supply picture at the time.
3. Refuse to bid on a procurement where there is already adequate mold capacity on the item in the industry.
4. Examine present jobs and, where plastics are found to be only a poor substitute for some other material, discuss with the customer the advisability of returning to the preferred material. This will serve two purposes: first, it will release a needed plastic material for a more important use; second, it will improve the functioning of the end product if the better material be used.

In connection with this last measure, the services of the Conservation Division of the War Production Board and its corps of specialists are at the disposal of industry to assist in determining the proper material, from the standpoint of availability and performance, for the job.

It should be reiterated that true conservation, in plastics as in any other field, is not the expending of precious time for the saving of odds and ends, nor is it the refusal to employ usable materials. It means rather the application of wisdom in the use of both materials and time.

• • •

OPA COMMITTEE FOR THERMOSETTING LAMINATES

The appointment of an Industry Advisory Committee of 5 members from the Plastic Thermosetting Laminate industry was announced Aug. 10 by OPA. Members are: D. J. O'Conor, president, Formica Insulation Co.; C. C. Steck, president,

* Plastics Consultant of the Materials Branch, Conservation Division, War Production Board, Washington, D.C.

Spaulding Fibre Co.; William H. Milton, manager, Plastics Dept., General Electric Co.; R. R. Titus, president, Synthane Corp.; C. R. Mahaney, Panelyte Div., St. Regis Paper Co. The committee will advise and consult with OPA on pricing problems of the industry, including a rollback of prices on thermosetting laminates. This is the first of 3 committees on plastics which OPA is considering. The next 2 will be on plastics machinery and on administration of MPR-406 (Plastics and Resins).

ACETATE ORDERS DIVIDED UP

WPB officials would like to have it known that they do not deliberately switch orders for molding cellulose acetate powders from one manufacturer to another just to be arbitrary or cantankerous. When a molder learns that his order has been switched from Company A to Company B, he may be curious or resentful for 2 reasons: first, he has dealt largely with Company A in the past and prefers to give him the order; second, he may feel that Company A is getting a "raw" deal. WPB officials point out that the only reason for changing the supplier is because Company A is tied up with more essential orders, and they deem it necessary to transfer the order to Company B or C in the interest of expediting final delivery.

CELLULOSE NITRATE USES LIMITED

There has been some questioning of WPB's policy in failing to release cellulose nitrate plastics for whatever end use the manufacturer wished because it is known to be in rather plentiful supply. WPB's unofficial answer runs about like this:

It is true that this plastic is comparatively free, and WPB will encourage production of essential civilian items of cellulose nitrate plastic whenever possible, especially as a substitute for other plastics and because the Armed Forces will take almost nothing made of nitrate. But there are other factors that make it necessary to limit its use almost entirely to strictly essential items. In the first place, nearly all manufacturers of cellulose nitrate plastics also manufacture cellulose acetate plastics, and naturally the Armed Forces would rather have their equipment used for the manufacture of acetate which can be converted into military goods. In the second place, some plasticizers used for both acetate and nitrate plastics are still short, although there is a plentiful supply of camphor which can be used freely with nitrate. Furthermore, cellulose itself is not too free. Third, the same old bugaboo—manpower. There simply are not enough men for everything and in choosing which production line to man, the factories always are requested first to man the line that is producing war goods, or at least essential civilian goods.

ACETIC ANHYDRIDE ORDER REVISED

The allocation order restricting the purchase of acetic anhydride has been revised to cover purchase of acetic acid and acetaldehyde under amended Order M-243, issued Aug. 7, effective Sept. 1, 1943. Directives were issued to control distribution during August. As revised, the order calls for the use of allocations form PD-602 for all deliveries by suppliers, and the use of PD-600 by prospective purchasers of any of the chemicals in any month in amounts exceeding 27,000 pounds. Estimated production and requirements for acetic acid indicate a shortage of 50,000,000 lb. in 1943 and 86,000,000 lb. during 1944. Production, which is expected to remain constant through 1944, unless it is decided to expand facilities, is about 526,000,000 pounds.

Acetic anhydride is of interest to molders because it is one of the principal raw materials used in the manufacture of cellulose acetate, cellulose acetate butyrate and cellulose acetate propionate. It is also used in aspirin, explosives, synthetic vitamins and other products. Acetic acid is used in acetic anhydride, dyestuffs and several acetates used as plasticizers. Suppliers will no longer be able to obtain this raw material except as specifically authorized by WPB, who in turn will insist that they must know what the final end product is going to be. Users will be expected to cooperate fully with their suppliers in furnishing this information as directed by WPB. It is probable that users of cellulose esters will have more difficulty in getting them in the future, unless their records of end uses are carefully prepared and presented. But defenders of this order believe it will result in more equitable distribution and claimant agencies will have a better opportunity to present their individual cases.

MAKE TELEGRAMS MORE ACCURATE

Officials in the Chemicals Division of WPB advise that letters and telegrams from the trade are coming in with incomplete information. They request that inquiry made by wire or letter concerning certain orders contain specific identification of both the commodity and the form or case number. As a sample telegram they suggest: "Please advise status WPB-2945 or 2946 application phenolic molding powder filed August 10."

WPB-2945 is the old PD-600 form; WPB 2946 is the old PD-601. Note that both commodity and form number are specifically given. Some telegrams are delayed in handling as much as a day and a half when either one of these items is omitted from the report.

The new forms are considerably smaller than the old but differ in no other fundamental respect. The purpose of the new forms is to permit greater ease in typing and to permit the forms to be returned to applicants in window envelopes. The old forms will be withdrawn as rapidly as the new ones are available. Inasmuch as a number of private print editions of these forms have been brought out, the Chemicals Division urges all applicants to obtain the new copy from WPB Field Offices and to discontinue using the old forms as soon as possible.

DISTRESS UREA MOLDING POWDER AVAILABLE

One of the producers of urea formaldehyde molding compound has accumulated a considerable quantity of distress urea molding powder over a period of a few years, and has now found a way to reclaim this material into a usable molding compound. With the knowledge and collaboration of WPB and the other producers of urea powder, this material is currently being offered for heretofore prohibited end uses such as wine and liquor closures.

It should be pointed out that this material is definitely inferior to first-grade compounds, and though offered at a discount, the material may etch or stain molds unless the molds are polished daily or have a good chrome-plated finish. All requests should be made on PD-600 forms to the WPB (under General Preference Order No. 331), clearly stating the primary product and end use.

CONTAINER PROBLEMS

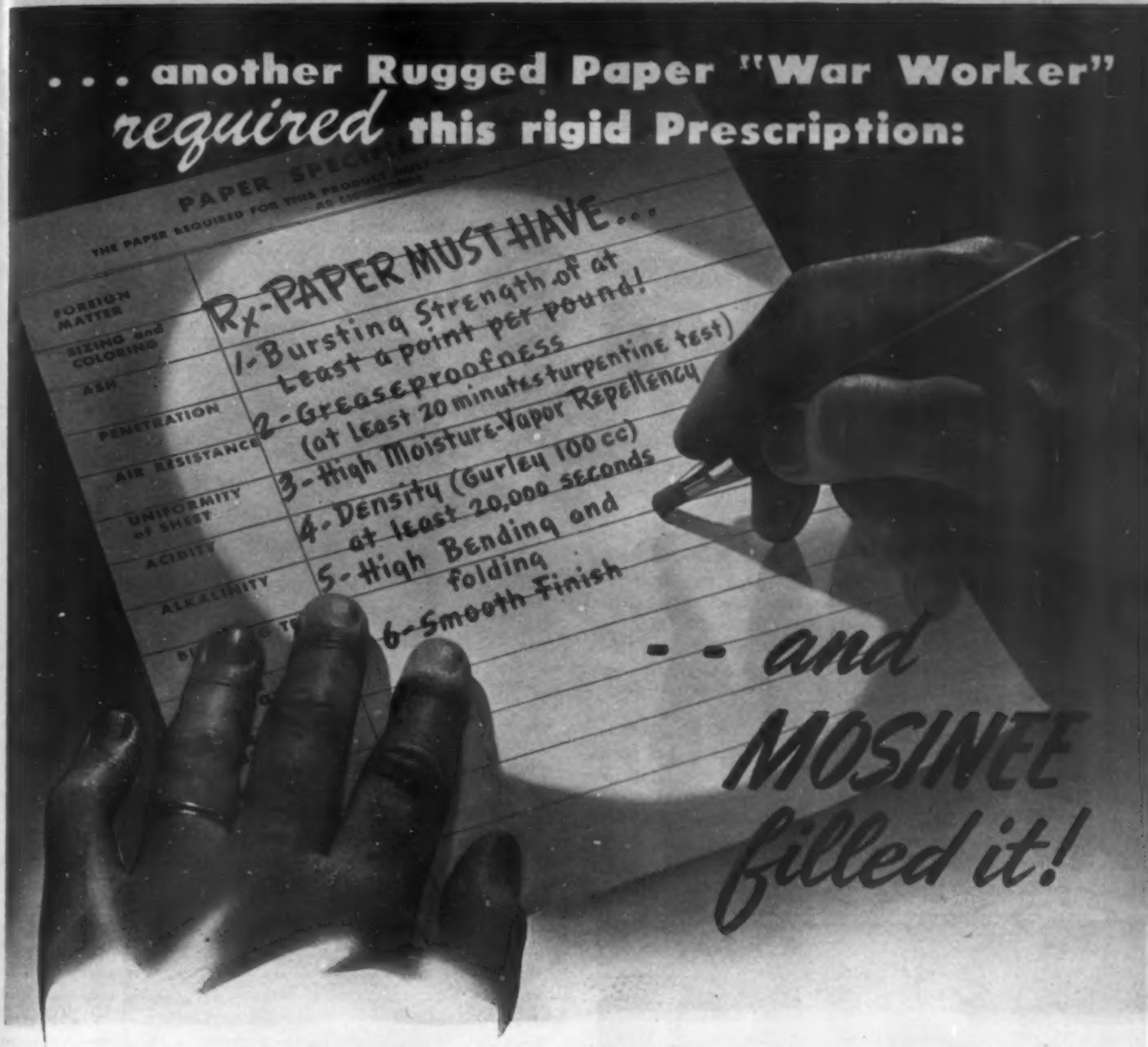
In the second meeting held between WPB and members of the industry on Aug. 3, 1943, plans were worked over for the possible use of multiwall bags to replace fiber drums in shipments of phenolic molding powders. It is not the intent of WPB to force such action when impracticable, but officials are urging industries to make such substitutions wherever possible. They are also urging molders to desist from shipping their finished product in used fiber drums which came to them originally filled with molding powder.

ALLYL ALCOHOL ALLOCATED

Allyl alcohol was placed under allocation by the War Production Board on Aug. 10. This chemical is used in the manufacture of clear glazing resins and laminating resins and other products upon which experimentation is still progressing. Allocation Order M-342 is to enable the Chemicals Division to direct the distribution of the limited supply of this chemical into the most useful channels.

COAL TAR UNDER SEPARATE REGULATION

Maximum Price Regulation 447—Coal Tar, issued by the Office of Price Administration, Aug 14, 1943—takes this industrially vital commodity from the (*Please turn to page 158*)



Food must get to our armed forces in excellent condition. The containers must resist the ravages of all territories and changing conditions. The paper industry has expended great energy and capital to meet this problem. Mosinee technicians have made a contribution to this field by developing the product described above. This paper combines greaseproofness and high density and retains the basic strength of the sulphate fiber for improved bending, folding and scoring.

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IN THE NEWS

★ AN ALL PLASTICS SHOW IS BEING SPONSORED BY the Society of Plastics Engineers, Detroit chapter. To be held on October 8 in the main exhibition room of the Engineering Society of Detroit, located in the Horace H. Rackham Educational Memorial, the show will contain representative pieces from material manufacturers, molders, machine tool builders, mold builders and other companies concerned with plastics. The plastics exhibit of over 1500 items, sponsored by MODERN PLASTICS magazine and recently on display at Yale University, will be moved in its entirety to Detroit for the SPE show. Various governmental agencies also are cooperating to insure the success of the exhibit, and invitations to exhibit their work have gone out to members at large of several national engineering societies as well as to the plastic industry.

In addition to the plastics exhibit, the meeting on October 8 will feature such speakers as Dr. Franklin Strain, Columbia Chemical Division, Pittsburgh Plate Glass Co.; T. D. Perry, Resinous Products and Chemical Co.; C. F. Kettering, president of General Motors Research Division; and Charles A. Breskin, Modern Plastics, Inc., who also will show moving pictures entitled "This Plastic Age." The program, a one-day affair, will be continuous from 9 a.m. until 10 p.m.

★ ISLYN THOMAS, FORMERLY ASSOCIATED WITH Consolidated Molded Products Corp., Scranton, Pa., has been made general works manager of Ideal Plastics Corp., Long Island City, N. Y. Mr. Thomas also is on the faculty of the Brooklyn Polytechnic Institute, specializing in teaching plastics and plastic mold design as a part of the engineering science and management war training classes which are sponsored by the U. S. Office of Education.

★ "PLASTICS TODAY AND TOMORROW," AN EXHIBIT developed by MODERN PLASTICS magazine and until recently on view at Yale University, is moving on or about September 1, to the Architectural League, 115 E. 40th St., New York, N. Y. During its stay in New Haven the exhibit was seen by hundreds of students, college professors and soldiers in training at the university (see photograph above).

In New York it will be part of an exhibit sponsored by the Architectural League in conjunction with such groups as the New York chapter of the American Institure of Architects, the American Institute of Decorators and the Designers' Research Group. The League is planning to conduct numerous symposiums in connection with the New York showing which is expected to last for about three weeks.

★ AMERICAN GAS ACCUMULATOR CO., ELIZABETH, N. J., has announced the acquisition of Stimson Reflector Co., Chicago, Ill., which now operates as Stimson AGA Plastics, Div. of the AGA Co. J. C. Stimson remains as general manager of this Chicago plant which will continue to manufacture reflectors and lenses in transparent plastics.

★ WILLIAM M. RAND, VICE-PRESIDENT OF MONsanto Chemical Co., St. Louis, Mo., and general manager of the Merrimac Div., has been elected to the executive committee of the company effective November 1. He will be succeeded as vice-president by Daniel S. Dinsmoor, assistant general manager of the Organic Chemicals Div. Osborne Bezanson, vice-president and general manager of the Texas Div. will become general manager of the Organic Chemicals Div. on November 1, succeeding Julius A. Berninghouse who will retire on that date.

J. EARL SIMONDS

★ J. EARL SIMONDS HAS RESUMED HIS CONSULTING practice with offices in the Chanin Building, 122 E. 42nd St., New York, N. Y. He will specialize in analysis and evaluation of commercial aspects of new plastic and resinous material; plant layout and installation; mold, tool and product design; new applications and techniques; and postwar planning and investigations. Mr. Simonds recently resigned as eastern technical director of the Plastics Industries Technical Institute.

A native of Clarkwills, N. Y., Mr. Simonds received his mechanical and electrical training at Pratt Institute, acquiring his chemistry and chemical engineering knowledge the "hard way," through home study. He entered the plastics industry in 1923 as a partner in the firm of Havekost & Simonds, engineers and designers. In 1929 he joined the technical staff of Synthetic Plastics Corp., now the Plastics Division of American Cyanamid Co., where he was engaged for over 6 years in commercial research work, in the development of new urea applications and in liaison work between the laboratory and molding plants through the country. It was under his supervision that the first "all out" urea molding plant was planned, built and equipped.

In 1935 Mr. Simonds opened offices as an independent plastics consultant subsequently serving many prominent firms both here and abroad. While affiliated with the Plastics Institute, he taught and lectured on plastics and techniques at the Institute in Los Angeles. Returning to New York, he was active in organizing the Eastern Division of the Institute and directed all technical activities of that division.

Mr. Simonds has written numerous articles on plastics and related subjects, and he is a frequent speaker before professional and trade organizations. He is a member of the Society of The Plastics Industry, and The Association of Consulting Chemists and Chemical Engineers, Inc.

★ CONSTRUCTION OF A 3-STORY, HEAVY CONCRETE addition to the Leominster plant of Standard Tool Co. was announced recently by Lionel B. Kavanagh, president and treasurer. Enlarging the floor space of the plant by 50 percent will enable the company to increase the number of its employees. The addition also will provide room for a larger constant temperature controlled inspection room, and for rest rooms and a hospital. Devoted 100 percent to war work, much of the company's production is gages and molds. *(Please turn to page 134)*

★ THE ACADEMY AWARD OF THE AMERICAN Society of Industrial Engineers was presented on June 30 to Thomas Saffady, president of Sav-Way Industries, Detroit, Mich. The award was in recognition of Mr. Saffady's outstanding contributions to the progress of industrial engineering and to the war effort through the record output of his company.

★ THE JUNIOR CHEMICAL ENGINEERS OF NEW York, 330 W. 42nd St., have announced the election of the following officers: president, Lt. Raymond P. Devoluy, U. S. Navy Materials Laboratory; vice-president, Edward T. Maples, M. W. Dellogg Co.; secretary-treasurer, Andrew E. Chute, Foster-Wheeler Co.; and asst. secretary-treasurer, Frank Melaccio, Fratelli Branca & Co.

★ IN RECOGNITION OF HIGH ACHIEVEMENT IN the production of war materials, employees and management of the Pittsburg, Calif., plant of the Great Western Div., Dow Chemical Co., received an Army-Navy "E" award on July 28. Other plants of this company to receive similar awards are those which are at Midland and Bay City, Mich., and at Velasco and Freeport, Texas.

WILLIAM H. MILTON

★ THE ARMY-NAVY "E" WAS PRESENTED ON JULY 23 to the Pittsfield Works of the Plastics Division, Appliance and Merchandise Dept., General Electric Co. In accepting the flag from Brigadier General Guy H. Drewry, William H. Milton, manager of General Electric's Plastics Division, spoke of the award as a recognition of the "little people" of this war who produce hundreds of different plastic parts which later become essential units in planes, tanks and ships. One outstanding performance of the Pittsfield plant was the perfection of mass production output of a complicated plastic trench mortar fuse which must be made so exactly that each fuse requires 64 gaging operations before passing inspection. Another interesting plastic part produced by this plant is the loop antenna housing enclosing radio aerials on American bombers, which employs waste clippings from Army shirt tails as filler. Master of ceremonies at the presentation was Louis S. Gleason, manager of the Pittsfield plastics plant.

★ TAYLOR INSTRUMENT COMPANIES, ROCHESTER, N. Y., have been awarded the Army-Navy "E" in recognition of outstanding production. Col. John A. Rogers made the presentation of the flag which was accepted by L. B. Swift, president of the company.

★ A SECOND ARMY-NAVY PRODUCTION AWARD HAS been presented Calco Chemical Div., American Cyanamid Co., Bound Brook, N. J., for production of organic intermediates going into munitions, rubber chemicals and special fuels and for production of dyestuffs for military uniforms, camouflage, sea markers and signal devices.

★ EMPLOYEES OF THE BRISTOL CO., MAKERS OF recording and controlling instruments, have been awarded the Army-Navy "E" for outstanding production of war matériel.

★ JOHN H. HOLTON, VICE-PRESIDENT OF CARRIER Corp., Syracuse, N. Y., has announced the appointment of C. Robert Powers as production control manager of the Manufacturing Div. with responsibility for the preparation and control of all manufacturing schedules, delivery and flow of material.

ROBERT A. BOYER

★ ANNOUNCEMENT HAS BEEN MADE OF THE RESignation of Robert A. Boyer as head of Ford Motor Co. Chemurgic Laboratories. Under his direction, the Ford research laboratory, in addition to other work, perfected processes for extracting soybean oil, developed soybean paint and devised a method of utilizing low grade ores and fabricating without melting or machining. Mr. Boyer in his new position as development director of Brackett Co., Cincinnati, Ohio, will continue work on the development of soybean fibre.

★ AT A RECENT MEETING OF THE BOARD OF DIrectors of Brown Instrument Co., Philadelphia, Pa., George M. Muschamp was appointed vice-president in charge of engineering and Paul L. Goldstrohm vice-president in charge of production.

★ EMPLOYEES FROM THE PLASTIC PLANT OF E. I. du Pont de Nemours & Co., Inc., Arlington, N. J., gave the first public demonstration of the forming of transparent plastic enclosures for bombers, pursuit ships and other military planes on August 9 through 14 at the War Manpower Commission's "Get a War Job" rally in Military Park, Newark, N. J. A regular unit of workers from the du Pont plant formed 3-dimensional landing light covers for the Grumman Avenger—covers which were shipped from the demonstration to the factory for installation. The exhibition showed the placing of rigid sheets of Lucite in an

electric oven, the sheets' pliability when heated, the ease of formation over a wooden die, the way in which the Lucite sheets hold the desired shape when cooled and such finishing operations as edge trimming and polishing (see picture above). Other plastic items on display at the booth which was open free to the public each day were surgical sutures of nylon, brushes with nylon bristles, Army raincoats made from a plastic-coated fabric, seamen's life jacket lights and water filters.

K. E. M.

An Outstanding Molding Compound and an Expert Molder Join Hands

The Result

This beautiful Chesterfield Cigarette display tray for Liggett and Myers Tobacco Company, molded by the Niagara Insul-Bake Specialty Co. of Albany, New York, from K.E.M., the one great and outstanding contribution toward Phenol and Formaldehyde conservation.

The large display tray, weighing 19 ounces, required *no* Phenol and less than 2 ounces of Formaldehyde.

Niagara Insul-Bake Specialty Company, with a reputation for artistic design and effective commercial molding, were the first to visualize the contribution K.E.M. had made to the Plastics Industry and pioneered the first large molding job of K.E.M.

Investigate this less-critical compound for your next molding job. If the End-Uses are sufficiently essential, use of Phenol up to 15% is being allocated to produce a stronger K.E.M. with qualities comparable to the usual phenolics.

Along with the development of K.E.M., MAKALOT Phenolics remain supreme in their field for that War Contract or that tough molding job. Inspect this typical list for the solution of your problem.

#1040—The best Low Loss compound yet developed for MFE work.

#1163—Available for CFG contracts. Unsurpassed in molding and final quality.

#93-C—For CFI-10 work. Approaches CFI-20 in strength, yet has flowing and molding qualities equal to many wood-filled compounds.

#2962—Supreme for the past 7 years for satisfactory mold shrinkage. NEVER cracks around inserts. Supplied for Compression, Transfer and Jet Molding.

"KEEP 'EM MOLDING"

FABRIC & PAPER IMPREGNATING RESINS · MOLDING COMPOUNDS · UREA RESINS & ADHESIVES · PHENOLIC LACQUERS · VARNISHES

Makalot

CORPORATION

262 WASHINGTON ST., BOSTON, MASS.

Central States Representative: C. R. Olson, 1020 15th St., Rockford, Ill.

Pacific Coast Representative:
Milton Turk; 1425 S. Flower St., Los Angeles Calif.

The Independent Producer of Superior Plastics

★ L. H. AMRINE, PRESIDENT OF IMPERIAL MOLDED Products Corp. and proprietor of Imperial Tool Works, has been elected to the Board of Directors of the Chicago Section of S.P.E. Mr. Amrine replaces E. S. Rinehart who has been transferred to the St. Louis office of Spaulding Fibre Co., Inc.

★ AT THE AMERICAN CHEMICAL SOCIETY'S PITTSburgh meeting on Sept. 6, the Industrial and Engineering Chemistry Division held a symposium on research management in small laboratories. Presided over by F. J. Curtis, development director of Monsanto Chemical Co., the symposium considered the best methods of conserving chemical research facilities through the full use of small and medium sized laboratories. Representatives of chemical, engineering and consulting firms participated.

★ DR. RAY B. CREPPS, DIRECTOR OF THE MATERIALS testing laboratories at Purdue University, on Sept. 1 joined Owens-Corning Fiberglas Corp. as director of the testing division of the company's research laboratories at Newark, Ohio.

★ WEATHERHEAD CO., CLEVELAND, OHIO, PROducer of tube and pipe fittings, last October started a training program in plastics. The project, sponsored by the U. S. Office of Education under the supervision of Fenn College, had the object of supplying a nucleus of skilled workers schooled in the design and production of plastics so that the company would be in a position to convert some of its products to plastics. Previously the Weatherhead Co. had supplied many plastic parts but had not manufactured them in its own plants.

The course is divided into 2 classes. After completion of a 16-week beginning course, the students shift to the advanced class and are succeeded by a new crop of beginners. Both classes meet twice each week for 2-hour sessions. Supplementing the PLASTICS CATALOG which is used as a general guide, each student keeps a notebook which he is encouraged to maintain for future reference. The course is carefully outlined, one subject being covered completely before another is taken up. Warren V. Price, plastics engineer for the company and instructor in these classes, has found that blackboard explanations often prove more beneficial than hours of oral description (see picture above). Plastic samples and motion pictures are used when possible to illustrate a point at issue. Classroom work is supplemented by demonstrations of actual molding processes. Intentionally incorrect molding methods sometimes are used to emphasize such things as the importance of correct molding cycles. Throughout the course students are encouraged to draw their own conclusions after the facts have been given them. From time to time advanced students make inspection trips to other plants. Graduates are advised to study trade literature.

Sorry!

★ IT HAS BEEN CALLED TO OUR ATTENTION THAT in the August issue, page 69, Item 9, we failed to mention that the tubing used in the manufacture of the U. S. Drum and Fife Corps plastic fife is Tulox TT tubing extruded by Extruded Plastics, Inc.

★ WE ARE INFORMED BY THE CELLANESE CELLUloid Corp. that the company's Lumarith X has been specified for the housing of the Air Corps flashlight described on page 63 of the May issue.

S.P.I. News

Plans for the fall SPI meeting are going forward rapidly under the active sponsorship of the Committee on Arrangements. The speakers' program is shaping up nicely and the Committee has announced that among the several speakers who already have accepted places on the program is the Honorable Fiorello H. LaGuardia, Mayor of the City of New York. The important matter of "War Contract Termination" is to be discussed by Eric A. Cammon, member of the accounting firm of Peat, Marwick, Mitchell & Co., while Architect Alden Dow is to address the meeting on "Plastics in the House of the Future." Both subjects cover matters which we hope will be of early concern to the industry for they will vitally affect the industry in the postwar period and, as such, merit consideration in all future plans. Two new members have been appointed to the Fall Meeting Committee. Mrs. E. W. Levien is to be in charge of the entertainment for the ladies, and C. W. Marsellus is to have supervision over a plastics exhibit, one of the many innovations in the plans for this year's Fall Conference.

• • •

Second in the series of 4 monthly meetings of the New York Chapter was held at the Hotel Waldorf-Astoria in New York City on August 19. Phil Carroll, Jr., business consultant, addressed the group on "Incentive Wages." He pointed out the advantages to be gained by plans of this type and cited many examples of the increase in productivity per man and machine in plants where the incentive principle is employed. Because of the evident widespread interest in the series of discussions, résumés of the talks and principles involved are to be made available to all SPI members in printed form. The first booklet will cover "Job and Individual Merit Rating," the subject of C. H. Uhlir's address at the meeting on July 15. Herbert Spurway, Boonton Molding Co., will address the third session on Sept. 16, on the subject of "Load and Progress Charts."

• • •

One of the most active groups in SPI and one which gives every evidence of continuing out in front is the Post-War Planning Committee headed by Charles P. Livingston. The main objective of this committee, whose initial meeting was held in New York City on August 6, is to make sure that the plastics industry holds the ground it has gained during the war and takes the most efficacious approach to furthering its postwar trade position.

• • •

J. D. McDonald, chairman of SPI Pacific Coast Section, has recently been elected chairman of the Los Angeles Chapter, and Dwight Hirsh, secretary-treasurer. Roy Peat was elected chairman of the Pacific Coast Technical Committee to serve as representative on the National Technical Committee.

• • •

A meeting of the SPI Technical Committee Sub-Division chairmen was held in Detroit, Mich., on July 29, to set up a program for the current year. Among the projects on the agenda is the development of an engineering classification of plastics to be handled by a committee appointed expressly for the purpose. In addition to that important project, the committee is to assemble data and information on insert design, molding tolerances, processing methods, mold design, dimensional stability, design criteria, machinery methods, finishing and test methods.

Due to the paper shortage, an index to Volume 20 of *Modern Plastics* (Sept. 1942–Aug. 1943) is not included in this issue. A limited number of indexes has been printed, however, and these are available to subscribers who request them from the Readers' Service Dept.

Power operated turret on a Martin Marauder with hard hitting twin 50-calibre guns ready for combat.

Photograph courtesy of The Glenn L. Martin Co.

FUNCTIONAL DESIGN IN PLASTICS

... exemplified in

Gun Turret Control Grips

These molded grips place and *keep* "the situation in hand" for aircraft gunners in power-driven turrets by providing instant, continuous control over communication, gun firing and turret rotation. Each grip has firing trigger, power control lever (which breaks circuit on release of hand pressure) and thumb-switch for inter-communication and high-speed rotation of turret. A pair can be used in combination to accommodate from 2 to 6 circuits; the same circuit can be operated from both grips or independent circuits can be wired to each.

The grips resulted from research and evolutionary design by our staff. In addition to maximum operating efficiency, compactness and weight-saving features, they had to be durable under extreme conditions of service. We produce them to withstand a temperature range of $-70°$ to $180°$ F.

PM

THE SYMBOL OF ENGINEERING EXPERIENCE AND MOLDING SKILL

PLASTIC MANUFACTURERS

INCORPORATED

INJECTION AND TRANSFER MOLDING

FORMERLY THE THOMAS MASON COMPANY, INC.

STAMFORD, CONNECTICUT

LONDON LETTER

THE two main present developments in the British plastics world, apart from steady progress in fields of research and substitution, are 1) strong moves by leaders of the plastics industry to persuade the British Government to give its assistance in developing *home* production of plastics raw materials on a scale far larger than ever before; 2) the launching of widespread publicity on behalf of the plastics industry as a whole—publicity designed not only as goodwill propaganda, but also as an effective means of counteracting many wild misconceptions and exaggerated claims going around about the future of plastics.

Details of the publicity plan have been given by Major Stanley M. Mohr, chairman of the British Plastics Federation, speaking at the Federation's annual meeting. "The magnetic attraction to investors of shares bearing the magic title Plastics has been very noticeable of late, but I am not sure that this state of affairs is altogether desirable," he said. "The public should know that the plastics industry in this country has many obstacles to overcome and innumerable problems to solve before it reaches full maturity and is not necessarily the Eldorado which people imagine."

Major Mohr went on to reveal that the Council of the Federation has been preparing a propaganda campaign with the long-term objective of promoting public recognition of plastics as a class of many high quality, reliable materials, of widely differing characteristics, which make each material ideally suitable for many and varied purposes. At the same time, the campaign will endeavor a) to kill the belief that plastics are extremely cheap and therefore nasty; b) to kill the belief that all plastics are really one magic material (probably made from milk) that can do anything; c) to explain the various types of plastics, their limitations, uses and applications. Funds for this campaign, which will be on a national scale, will be provided by voluntary subscriptions from various member firms of the Federation. Incidentally, this campaign is only one of many new and vigorous measures which the Federation is planning in order, as Major Mohr expressed it, "to get our house in order in good time with an eye to the future." Greatly increased revenue is to be sought, and it is hoped to weld together all sections of the British plastics industry into one united body, to help towards increased efficiency and influence in postwar years.

The need for much greater home production of raw materials was stressed by Kenneth M. Chance, chairman and managing director of British Industrial Plastics, Ltd., one of our most progressive plastics firms, in his annual review accompanying the annual report of his firm. He pointed out that with the exception of cellulose, all the basic raw materials needed for the plastics industry were actually available in Britain. Unfortunately, conversion machinery was not available to the same extent, and very elaborate and costly plant would have to be installed before any progress could be made in the production of the chemicals required for conversion into plastics. He suggested that the interests of the country might best be served by confining this manufacture to one huge factory, and setting up a large monopoly chemical concern which would work in close conjunction with the plastics industry.

But Mr. Chance condemned the present state of affairs, complained that he found it "difficult to understand why even now there are few signs that the country's native resources will be utilized to the best advantage for production of these raw materials." Coal and limestone, the principal basic raw materials for plastics, were plentiful enough. The distillation of British-produced coal would provide most of the important raw materials and yield as a by-product gas for the generation of electricity. Yet the popular tendency still seemed to be to concentrate on the work done in the United States of America in deriving these raw materials from oil instead of coal. "Why in Britain should we slavishly try to imitate methods adopted by other countries for the utilization of their native resources which we do not possess, instead of devising methods of utilizing our own native resources?"

Meanwhile, further evidence of the move toward home production is contained in the listing by Dr. Herbert Levinstein, a research expert, of the plastics raw materials which it is now possible to make in Britain. These include phenolic plastics and derivatives (such as polyphenols), phenolic resinoids, amino plastics from urea and derivatives, cellulosic plastics, such as acetate and nitrate, glyptals, polystyrene and methyl methacrylate polymers. A further development has been the suggestion, supported in many quarters, that the British plastics, coal, gas, chemical and allied trades should pool their research resources with the object of directing plastic research to a commond end: that of ensuring a cheap, adequate and effective supply of raw materials. It is hoped that a new plan for spending £1,000,000 on research into the development of the coal industry and its byproducts will help in this direction. But it is realized that much bigger research, devoted more exclusively to plastics, is needed. The interesting developments in the United States of America, where the plastics industry is now regarded as so important that it is receiving actual financial assistance from the U. S. Government, is constantly being quoted as an example to be followed. So far nothing concrete has come from the Government, but the decision to go ahead with a huge hydro-electric scheme in Scotland, a result of which will be the setting up of innumerable new light industries, shows hopeful prospects.

A general idea of the Government outlook was given by Mr. L. P. B. Merriam, our Controller of Plastics, Ministry of Supply, in a recent speech. He pointed out that whereas at the beginning of the war only one section of the plastics industry was controlled, now every type of material was controlled either by statute or by voluntary direction—amounting in all to about 50 different materials. He emphasized the Government's principal concern being with the use of plastics for war production, revealing that today, in fact, *all* plastics in Britain were used specifically for war production purposes. He added that some of the materials were now being brought over from America under Lease Lend (as a consequence the Plastics Control has become a trading control, dealing in many millions of pounds per annum). But, added Mr. Merriam, there was an express arrangement that none of these imported materials should be used for export to non-Allied countries. Announcing that the raw materials position for 1943 was "satisfactory," Mr. Merriam drew attention to the large numbers of women now employed in plastics molding, etc. A questionnaire to 500 molding, manipulating and fabricating firms, he said, revealed that 80 percent of women operatives were engaged on "munitions production." Of the total number of women employed, 70 percent were working for member firms of the British Plastics Federation.

In conclusion I must emphasize the continued and tremendous activity in plastics investments. Firms such as Imperial Chemical Industries, Ltd., British Celanese, Ltd., and Thomas de la Rue, Ltd., are going ahead with their big-scale research schemes, which I mentioned in the last letter. Since then Mr. Samuel Courtauld, chairman of Courtaulds, Ltd., speaking at the annual meeting, has revealed that the company's research laboratories are to be extended on a much wider scale to investigate possibilities of extending the company's activities in both textile and plastics trades. Another interesting development has been the setting up of a subsidiary plastics company by a firm of aeronautical engineers, Cornercroft, Ltd. (who also have interests in Northern Aircraft and Engineering Products, Ltd.). The new company, Cornercroft (Plastics), Ltd., is to work on the development of precision engineering in conjunction with the "closely allied" industry of plastics. This development, of interest in plastics in the aircraft world, is worth noting, because so far we seem to have been behind other countries in this field. (*Mailed by Denys V l Baker.*)

Fiberglas plastics

(*Continued from page 88*) of J. D. Lincoln that he has had a Fiberglas reinforced plastic showing a tensile strength of 83,000 p.s.i. No data were given in his talk as to the related properties of that particular material.

A combination of specific gravity in the order of 1.6 to 1.8 with tensile strengths in the order of 45,000 p.s.i. or higher, obviously ensures an exceptionally favorable strength-weight ratio and makes these products superior in this respect to any metal used in aircraft construction. It may be worth while to examine the known physical properties of glass fibers and of the textiles fabricated from them.

Tensile strength of glass fibers

Figure 3, based on a published report prepared by Dr. F. O. Anderegg,[3] shows graphically the remarkable relationship between the diameter and tensile strength of glass fibers. The circles are drawn to visualize the various commercial sizes of Fiberglas fibers by enlargement from a common base. The curve indicates that the finer textile fibers having a diameter of approximately .00023 in. show a tensile strength well in excess of 250,000 p.s.i. From this point the curve rises very sharply. It is significant that glass fibers with a diameter below .00010 in. have tensile strengths as high as 2,000,000 p.s.i. These extremely fine fibers have been made experimentally in limited quantities and show promise of postwar importance.

Tests on individual fibers are merely indicative of the unique strength property of glass fibers. The realizable strength, after the fibers have been fabricated into yarns or cloths, is inevitably less than the strength of individual fibers and is influenced by the construction of the yarn or weave of the fabric and by the method of combining the reinforcement and the resin. The apparent fact that tensile strengths in the region of 83,000 p.s.i. have been achieved suggests that still higher strengths may some day be obtained, using standard textile fibers, when the fabricators learn how best to embody their reinforcement in the matrix.

Dimensional stability

Because individual fibers are like exceedingly fine glass rods —solid, not hollow—they do not absorb moisture within themselves nor do they shrink or swell under the influence of moisture changes. The coefficient of thermal expansion of glass is very low, and this property becomes negligible when the individual glass fibers are twisted into a strand.

Glass fibers are perfectly elastic—that is, their breaking

[3] "The Strength of Glass Fibers," by Dr. F. O. Anderegg.

TABLE I.—SUMMARY OF PUBLISHED DATA ON FIBERGLAS-REINFORCED PLASTICS

Physical properties of some Fiberglas-base laminates

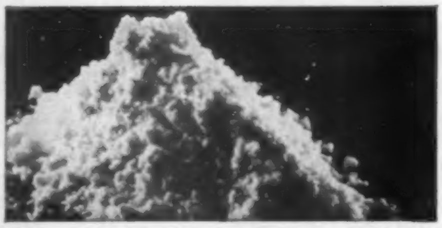
	[1]	[2]	*Longitudinal*[3]	*Transverse*	*Longitudinal*[3]	*Transverse*
Fiberglas base fabric	*	ECC-11-128	ECC-11-148		OC-63	
Type of resin	Phenol formaldehyde	Allyl†	Allyl†		CR-39	
Tensile strength, p.s.i.	14,000–20,000	41,500–49,400	27,400–40,700	18,500–37,500	76,400	800
Flexural strength, p.s.i.	20,000–27,000	22,000–28,700	4200–24,600	4200–25,400	59,000	2000
Flexural modulus, p.s.i.	1,000,000–2,000,000	1,750,000–2,080,000	310,000–1,510,000	280,000–1,630,000	4,040,000	850,000
Compressive strength, p.s.i.	42,000–47,000	55,300–63,100	25,400	52,200		15,000
Impact strength, notched Izod, ft.-lb. per in. of notch	5.0–6.5	20.0–24.6	13.6–25.0	12.9–16.0	23.9	10.0
Water absorption, percent						
24 hr.	0.3–0.5	0.3–0.6 (25° C.)	0.5–2.7 (25° C.)		...	...
168 hr. at 25° C.	.....	0.7–1.0	0.6–2.8		...	...
Specific gravity	1.4–1.6	.....	1.736	...	1.872	...

Average tensile properties of some Fiberglas-base laminates

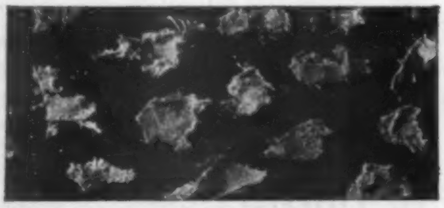
	Longitudinal	*Transverse*[3]	*Longitudinal*	*Transverse*
Fiberglas base fabric	OC-63		ECC-11-161	
Type of resin	Phenolic		Urea-phenolic	
Proportional limit—tangential, p.s.i.	4800	4600	3300	3900
Proportional limit—.01 percent offset, p.s.i.	7600	6600	4600	5500
Yield strength, .2 percent offset, p.s.i.	30,900	28,100	13,700	13,000
Ultimate strength	38,000	37,700	27,400	19,700
Modulus of electricity, p.s.i. $\times 10^6$	2.16	2.13	1.76	1.14
Elongation before fracture, percent	2	2	3.5	2.5
Specific gravity	1.64		1.74	

Cloth constructions: ECC-11-128—all glass; count, warp 42/in., fill 32/in. ECC-11-148—all glass; count, warp 30/in., fill 19/in. OC-63—glass warp, muslin fill; count, warp 54/in., fill 12/in., ECC-11-161—all glass; count, warp 29/in., fill 17/in. *Unidentified. †Columbia resin series (C. R. 10 C. R. 38, etc.). [1] 1943 PLASTICS CATALOG, Plastics Properties Chart. [2] MODERN PLASTICS *20*, 102ff. (June 1943). [3] MODERN PLASTICS *20*, 96ff. (June 1943).

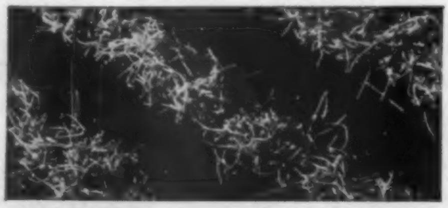
Two years ago, a Plastic gun stock would have shattered!



FILFLOC Pure cotton flock of surpassing cleanliness and uniformity.



FABRIFIL Macerated cotton fabric for extra strength; uniformity assures good flow.



CORDFIL Evenly cut lengths of tire cord; for plastics of utmost strength.

TODAY'S PLASTICS ARE FAR STRONGER THANKS TO RAYCO COTTON FILLERS

With America's involvement in War, there sprang up a tremendous demand for strong plastics to replace or complement scarce metal parts. Thermosetting plastics using wood flour fillers were found to lack the strength essential to dependable performance under severe operating conditions. Army, Navy, Air Force and Lease-Lend tests revealed that plastics filled with cotton flock such as Rayco cotton "Filfloc," possessed the requisite strength. As the ingenuity of plastics engineers made possible the molding of larger articles, fillers of greater strength were needed, and Rayco macerated cotton fabric "Fabrifil" was evolved to fill the need. Still further progress led to the devising of Rayco cotton "Cordfil," representing today's maximum achievement in filler strength.

Insist on compounds containing RAYCO-Fillers—for good flow and maximum strength.

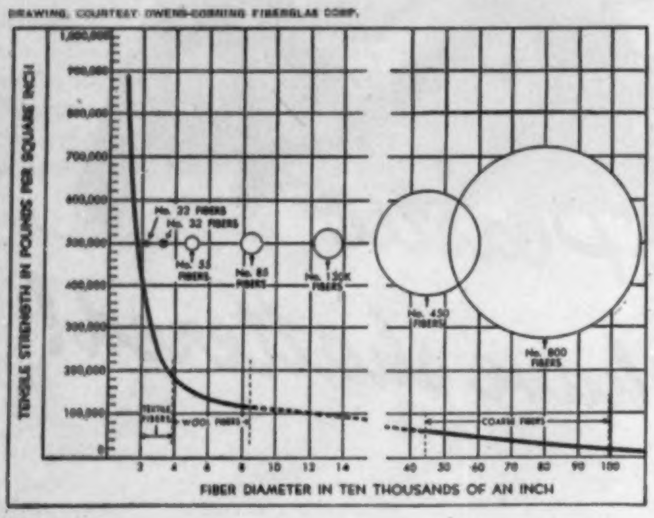
RAYON PROCESSING CO. of R.I. INC.

60 TREMONT ST., CENTRAL FALLS, RHODE ISLAND

Developers and Producers of Cotton Fillers for Plastics

strength and limit of elasticity are identical. There is no cold flow nor unsatisfactory fatigue phenomena. Tests show that individual glass fibers and the yarns made of them have a stretch of approximately 4 percent at tensions approaching their breaking strengths. This is not materially different from the stretch in hemp and some other organic fibers, but the tension required to develop that stretch is very much higher in Fiberglas. Thus, a pull that would stretch or rupture an organic-fibered fabric might have no apparent effect on an equivalent Fiberglas fabric because of the marked difference in ultimate tensile strengths. When the Fiberglas material is subjected to much higher stresses, the elasticity of the glass comes into play before failure occurs, largely explaining the high impact strength of properly designed Fiberglas-reinforced plastics.

DRAWING, COURTESY OWENS-CORNING FIBERGLAS CORP.



3—***The remarkable relationship between the diameter and tensile strength of glass fibers is sharply emphasized by this graph. The circles represent various commercial sizes of Fiberglas fibers by enlargement from a common base***

There is, of course, a moderate stretch in Fiberglas yarns and fabrics as in other textiles, attributable to the twist in the yarn or the weave of the fabric. When the fabric is coated or impregnated with a resin, the interstices in the fabric are filled and this stretch disappears.

Moisture adsorption and absorption

With organic materials, the gain in moisture content from exposure of a "bone-dry" material to air having a high relative humidity is called *absorption*, since the moisture enters the fibers and is not merely a surface phenomenon. Most organic materials shrink or swell and many lose strength from the effects of moisture—undesirable properties for reinforced plastics.

Glass fibers do not *absorb* moisture from the air but they may gain very slightly in weight—about $^1/_{10}$ of 1 percent when determined by precision methods—by acquisition of moisture from water vapor on the surface of the fibers. This extremely low moisture *adsorption* tends to aid in establishing and maintaining an intimate bond between the fibers and the resin, preventing entrance of moisture through or around exposed ends of fibers. Since in aircraft applications gain in weight due to atmospheric changes may amount to a great many pounds in a large ship, the low moisture adsorption of Fiberglas is one of the factors contributing to its use as a thermal insulation and acoustical material. While this property remains constant with respect to the Fiberglas employed as a plastic reinforcement, it becomes negligible so far as that product is concerned if the resin itself gains in weight by moisture absorption.

Compatibility of resins with the glass

Since glass fabrics normally are made with a sizing or surface coating on the individual fibers, this coating must be taken into consideration in treating Fiberglas material with the selected resins. In some cases the coatings normally used appear to aid in securing the desired bond while in others the coating must first be removed by heat-cleaning or washing the fabric.

Although fire resistance is a desirable property in all aircraft parts, it is of minor importance in the face of other objectives which govern the selection of materials. Fiberglas is completely incombustible in its untreated form, but when subjected to heat or fire the glass fibers may soften or melt (at temperatures around 1000° F.). Here again the property is of no significance unless the selected resin is also incombustible or slow burning.

Durability

Glass fibers possess exceptional chemical stability, and have an indefinite life under normal conditions of exposure or use. Because the fibers present a very large surface area in relation to mass, they are somewhat more susceptible to the action of acids and alkalis than the same glass in mass form. This characteristic is offset by the use of extremely resistant and stable glass compositions.

While it is too early to estimate the durability of glass as a component in reinforced plastics, it is probable that its life will greatly exceed that of the matrix. In this connection, the one factor that must be taken into consideration is fiber abrasion due to excessive flexing. The individual fibers in a fabric have a tendency to rub one against the other under flexing conditions causing fiber breakage and eventual weakening of the fabric. This action is partly offset by the use of fiber lubricants applied before the yarn is constructed. However, since the lubricants may be destroyed by heat or oxidation and not replaced by proper treatment, the manufacturers of Fiberglas fabrics do not recommend their application where constant or severe flexing is anticipated. When such fabrics are used as a plastic reinforcement, the factor of internal abrasion becomes a negligible consideration in the design of the end-product, since there is no published evidence that this abrasion has any effect on the durability and service life of laminates.

New army bugle

(Continued from page 86)

All types of jigs, fixtures and holding clamps were experimented with until eventually one fine day a perfect, completed bugle was produced. As is always the case in a new development, this one bugle was practically a museum piece, having cost many thousands of dollars to produce. As in all such cases, however, after the experimental work and tools had been paid for, the speed of production which is inherent in all plastic molding has made this conversion a worthy one.

Credit—Material: Tenite II. Molded by Elmer E. Mills Corp. for Chicago Musical Instrument Co.

Booster coil housing

(Continued from page 97) mold section was removed from the part by hand, reloaded into the mold and this cycle again repeated.

Even with the 3 minutes of chill, however, the unit was so pliable that it would not maintain its shape perfectly and an egg-shaped opening results. In order to eliminate this difficulty, a new step was introduced: the molded part was pushed part way back on the force plug while the loose section of the mold was being removed. Figure 5 shows a molded housing with the loose mold section still attached. Figure 6 shows the housing on the force plug just as this loose mold section is being removed.

After the loose section had again been replaced in its proper position in the mold, the molded part was removed from the force plug and set on a shrink plug. The part was allowed to cool on the plug before being put in a tote box. This eliminated to a great extent most of the egg-shaped openings, but those pieces that still distorted slightly were again heated and pushed down on the shrink blocks. Some of the parts continued to crack around the back but this was overcome by adding material to strengthen this section. This not only eliminated the cracks but also aided the material flow considerably, which in turn eliminated all porous parts. Detailed drawings of the booster housing (Fig. 7) will give the reader a clear idea of the problems encountered in the design of the tools.

This development, begun before the war, has been completed in time to meet the intensified demands of our military and naval air forces. Never again will it be necessary for the ground crews of our aviators to "jack up the hind wheel" in order to get the motor started. Positive in its action and instantaneous in its result, this baby miracle has again proved the worth of plastics materials in their proper place.

Credits—Material: Durez. Molded by American Insulator Corp. for Eclipse Aviation Div., Bendix Aviation Corp.

Navy training bayonet

(Continued from page 70) kick press. After the polishing operation, the guard is then ready to be assembled on the bayonet, where it is held securely in place by two rivets. After the assembly of the two grip halves, the bayonet is then ready for packing and shipping.

This bayonet job was started in the right way—that is, by producing an inexpensive experimental mold for a 3-in. section of the blade. By this means it was possible to determine the proper design of the blank and the proper molding conditions, and to calculate the approximate strength which the blade would have after molding. Also, by building this experimental single-cavity die considerable time was saved in getting into production.

It should be emphasized that this training bayonet has been a plastic item from the very beginning and does not represent a substitution of plastics for metal. It has, however, become the means of releasing thousands of steel bayonets for combat duty. Because the production capacity for steel bayonets throughout the country is somewhat limited, it was necessary to use some other type for training purposes, and the plastic bayonet was developed to fulfill a function for which the material is eminently adapted. The toughness and rigidity of phenolic resin board, its high impact strength and moisture resistance fit it for rugged service and condition it for hard wear. The ease with which the blanks can be molded and their low bulk factor are also important considerations where speed of production is essential.

While it is true that there is very little chance that one of Tojo's slant-eyed maniacs will be run through by one of these plastic bayonets, they will play an important role in teaching our sailors the rudiments of bayonet warfare so that when it is time for a little pig sticking they will not be caught napping.

Credits—Material: Bakelite phenolic resin board; Lumarith. Molded by Pro-phy-lac-tic Brush Co.

Victory garden insect spray

(Continued from page 83) like any other garden tools, their life is dependent on the care taken in their handling and storage between seasons.

Post-seasonal uses suggested for the fine, misty, continuous spray of this gun include indoor mothproofing, fly spraying and deodorant spraying. Farmers are using it, the manufacturer reports, to spray livestock, barns and milking stalls as an added precaution against flies and their constant menace to human health. It is also used to spray chickens and chicken coops with considerable saving in time because a constant spray is emitted.

An aid to the success of both amateur and professional gardeners in their efforts to relieve our coming food shortage by waging war on our insect enemies, this garden spray is unique in the plastics field in that plastics have not only helped replace scarce metals—the old metal spray gun weighed more than 1 lb. whereas only 2 oz. of metal are used in the entire assembly of this unit—but they also have permitted the designers to use paper and wood in conjunction with the plastic parts to produce an article which is rugged and balanced in construction and design.

Credits—Material: Tenite II. Spray designed by American Speciality Co. in collaboration with Plastic Engineering, Inc., the molder.

Aircraft sub-assemblies

(Continued from page 82)

Figure 6 shows a bracket support for a heater used in bombing planes. Formerly made of metal, brackets were hard to stamp out because of the depth of the draw and sharpness of the angles for the sides. A joggle or indentation in one corner also contributed to the difficulty of the bending and forming operation. Using the urea laminate, it was comparatively simple to put the patterns in the mold and employ a rubber diaphragm pressure to complete the shape. The molded bracket has passed weight load tests satisfactorily, with a large margin of safety.

The bomber observation dome ring shown in Fig. 7 is another laminated part made by the same low-pressure method. Mold work is progressing on other items for aircraft use, and the company is confident that the definite advantages of laminated plastics in such applications as these will ensure them a place in the postwar air picture, as well as in other industrial and commercial fields.

Credits—Material: Synton, based on Plaskon urea or Bakelite phenolic resin. Molder: King Plastics Corp.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In the markets of tomorrow, raw materials will battle raw materials. It will be steel vs. Plastics . . . wood vs. Plastics . . . glass vs. Plastics . . . rubber vs. Plastics . . . etc. ★ The future of Plastics depends upon their ability to do a better job for the particular purpose than the raw materials they replace. And, naturally, the benefit of the doubt will always lie with the traditional materials. ★ The time to evaluate your Plastics . . . and thus be armed with facts and figures . . . is now! We offer a complete Plastics Testing service covering serviceability, composition, and practical application. We have a specially designed, conditioned room for testing Plastics under all conditions of temperature and humidity. ★ To meet post-war conditions, we offer a special series of comparative tests in which Plastics are compared with the raw materials they are to replace. If test results are negative, suggestions for improvement may alter the picture. ★ We recommend prompt action in preparing your Plastics for civilian markets . . . with the aid of Testing. Write.
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Chrome plating molds

(*Continued from page 100*) is done dry. An aloxite finish can be used satisfactorily in some cases if a high finish is not required.

Polishing is an operation that should be done in the toolroom, since a toolmaker knows his dimensional limits, contours and radii, and when sharp corners should remain. It is then the plater's responsibility to maintain these conditions. Because of the high reproducibility of chromium, any defects in the mold surface are greatly accentuated. This fact should be given serious consideration when setting up polishing conditions.

Plating cycle

When the mold comes to the plater, it should be lightly cleaned and pickled to remove oxidation due to toolroom handling. Then it is brushed lightly with a soft bristle brush on a flexible shaft, using an Al_2O_3 (aluminum oxide) and sperm oil paste. The paste is washed off in an organic solvent and the brushing operation repeated, using dry aluminum oxide powder. This operation gives the mold surface the highest possible luster as a good reproducible base. Now it is ready for stopping off.

The outside or non-working sections of the mold are lacquered to confine current density to the actual area requiring plate. This area shall comprise the entire molding and flash sections to eliminate the danger of sticking. Holes in the mold proper are lacquered or plugged to prevent excess gassing which otherwise would keep plate very thin at these points. When plating inserts or wedges that have been pre-fitted, it is advisable to use sheet lead for wrapping prior to lacquering. This keeps the edges sharp and preserves dimensions on ground, fitted parts.

A few basic rack designs will make the mechanical set-up comparatively simple. The anode arrangement is made in "octopus" form for its simplicity of design as well as its flexibility (see Fig. 2), eliminating the long-drawn-out process of making a complicated anode for each job. The "octopus" is used to put the plate where it is wanted by pointing the wires into low corners and away from high points. When working with a chromium bath, a plating bath that sets an all-time low for efficiency, these properties are essential. While the "octopus" is designed primarily for complicated forces and cavities, flat anodes can be utilized for plating pins, button, plates, platens, etc., and cylindrical anodes used for cylindrical parts.

After much experimentation, the following bath has been found most suitable for mold plating.

CrO_3 (chromic acid) 400 G/L
H_2SO_4 (as sulphate) 4.0 G/L

By maintaining the 100/1 ratio, the solution showed greater conductivity, better throwing power, brighter color and more uniformity than other concentrations. All of the afore-mentioned properties contribute much to the successful application of chromium to mold surfaces.

A plated mold can be highly polished, assuming it was defect free and well finished prior to plating, without endangering contours or sharp edges. The hardness of the deposit will protect these factors during the final polishing operation, which is performed through the use of the felt bobs and chromic oxide rouge.

Matte finishes

In the old days, a matte finish was obtained by first molding the piece and then sandblasting it. As the demand for this finish increased, a quicker and more economical method was sought with the result that the mold was sandblasted, reproducing this matte texture yet preserving the plastic surface. The mold surface had to be re-sandblasted frequently due to the abrasive action of the plastic compound, which resulted in a shining up of the mold and non-uniformity of the desired matte. Then chromium plating entered the picture.

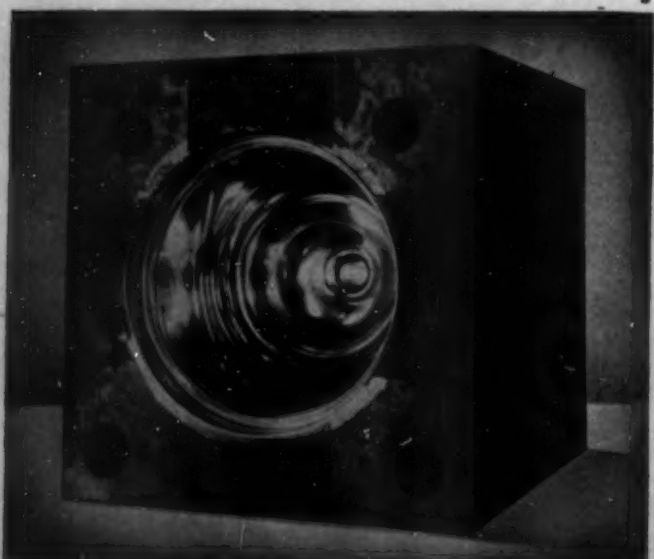
A technique that has been most satisfactory in reproducing consistently good matte finishes over a period of time follows:

1. Grit blast using No. 80 carborundum grit and at least 90 lb. pressure.
2. Rub surface very gently with French emery paper No. 000.
3. Plate with .001 in. thickness of chromium.
4. Repeat French emery operation, but gently.

The object in using carborundum grit is to achieve a heavier

3—A deep cavity with small center hole running straight through. Extraction problems and severe pitting of mold cavity were cured by chrome plating. 4—A 49-cavity mold running rag stock. Its efficiency has been increased 100 percent since it was chrome plated

3



PHOTOS, COURTESY HARTFORD CHROME CORP.

4


Accuracy
IN
PRINTING
LAMINATING
and
FABRICATING
of
Plastic
Sheets
Our exclusive laminating, fabricating, printing and platemaking methods have been developed to assure the precision production of computers, protractors, rulers, compass cards, dial and clock faces, gauges, charts, markers, nameplates and plotting boards, etc., for essential industries and branches of the Army and Navy.
Our facilities, unmatched even by raw material manufacturers, enable us to laminate to specification extra-large, extra-heavy, transparent, translucent and opaque thermoplastic sheets.
Maps, charts, diagrams, etc., printed on paper, can be permanently protected by the lamination of transparent thermoplastics over their surfaces. Our experienced engineers, welcoming the opportunity to cooperate in the development of your current or future requirements, will promptly estimate from submitted sketches or blueprints.
22½" of precision in printed, laminated and fabricated transparent Vinylite, resulting from our exclusive platemaking methods.
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270 MADISON AVE., NEW YORK 16, N. Y.

penetration of the surface. The French emery rub merely smoothes the high spots. The chrome plate protects the grit surface and, due to its higher resistance to abrasion, does not shine so readily. When a shining up eventually occurs it is on the chromium surface, the mold remaining unaffected. By stripping and replating, a new start can be made. Another distinct advantage of chromium-plated matte finished molds is the free extraction obtainable.

Reclaiming worn thread molds

A mold involving threads should be plated immediately upon its completion in the toolroom. Unfortunately, this is not the practice and many thread molds, worn below their dimensional limits, are heaved into the scrap heap. By employing techniques not too difficult to learn, a chrome plater can salvage a large percentage if not all of these molds. Where a thread grinder is available, the molds can be plated oversize on OD's and undersize on ID's and ground to size. The result is a surface far superior to the original. Where there is no thread grinder, those parts with a wide tolerance still can be saved.

Plating plastics finishing tools

Many of the tools used in the plastics finishing room can be plated with very encouraging results. Taps, due to the many types of harsh filler used in the plastic compounds, readily wear below dimensional limits. These worn taps can be brought back to usable condition by plating and, up to .002 in. per side thickness of chrome, work very well. In the case of new taps, .0005 in. to .001 in. thickness of chrome will outlast high speed and nitrided surfaces by as much as 5 to 1. At the same time, chrome's low coefficient of friction provides for cooler and cleaner operation of the tap. Drills can be plated with .0001 in. to .0002 in. thickness of plate for longer life. Heavier deposits will dull the cutting edges beyond efficiency.

Before plating, all tools should be heat treated at 600° F. for 30 min. and, after plating, for at least 2 hr. at 400° F. The treatment prior to plating is to relieve stresses and strains; the after-plating bake is to remove hydrogen occluded during the plating operation. The plating of files is successful only when chromium is applied in minute thickness from .00005 in. to .0001 in., since heavier deposits tend to remove the bite.

General uses of hard chrome

The use of chromium plating is almost unlimited. All types of machinery used in manufacturing plastics compounds are subjected to severe wear and corrosion. Thicknesses of plate ranging from .001 in. up to .010 in. can be utilized in the elimination of these two conditions, besides facilitating the cleaning of all machinery.

Pilling dies usually belly in the center and find an early grave. Plating undersize and grinding back to size gives a new die for the price of plating and grinding. The same procedure also aids in the preservation of the pilling punches. Curing forms, generally given to the molder in rough machine form, can be buffed and plated with .0005 in. thickness of chrome and still maintain the original dimensions.

The modern development laboratory uses plated molds, rolls, etc., and it is only reasonable that they should expect the molding shop to follow suit. A plated mold offers the following advantages: free extraction, higher finish of molded part, general all-around preservation of mold, and reduction in breaking-in time.

Aircraft design

(Continued from page 110)

For Case B,

$$\frac{F_{cys}}{E_{cs}} = \frac{F_{cyo}}{E_{co}}$$

where the face and core yield simultaneously, the expression for P_{cy}/b in terms of face thickness may be either Equation 23 or 25, and in terms of core thickness may be either Equation 24 or 26.

Then, for any combination of face and core material, the limiting compressive yielding load per unit width of panel may be plotted as a function of W/A for various face thicknesses and core thicknesses, resulting in 2 families of curves, one family for varying values of S and the second family for varying values of t. The selection of Equations 23 and 24, or 25 and 26 is determined by the evaluation of Equation 21. Thus, for Case A, use Equations 23 and 24. For Case C, use Equations 25 and 26. For Case B, use either.

On Figs. 16 and 17, Case C has been used, since $F_{cys}/E_{cs} < F_{cyo}/E_{co}$, or the Fiberglas and Alclad faces will each yield before the balsa core.[4]

It is noted that the value of the modulus of elasticity, E, in each case has not been altered to account for the effect of Poisson's ratio. Since Poisson's ratio was determined experimentally to average about .12 for balsa, the net effect on E_o is negligible. For Alclad, with a Poisson's ratio of .30, the effective change of E_s is less than 10 percent, and is therefore disregarded.

Explanation of Figs. 16 and 17

From the examination of Figs. 16 and 17, it is noted that 4 families of curves are plotted on each plate. The first 2 families represent the Euler buckling load as the parameter $P_E L_1^2/\pi^2 b = EI/b$ versus W/A for varying values of S and t. By introducing values of L_1 equal to a multiple of 5π the vertical scale can be changed to convert the ordinate into terms of P_E/b, or buckling load per unit width. In our case $L_1 = 10\pi$ inches.

The remaining 2 families of curves are plots of Equations 25 and 26, and represent the compressive yielding load per unit width of the selected panel. From Figs. 16 and 17 it is possible to predict the failing load per unit width of any sandwich combination in Alclad + balsa and Fiberglas + balsa at any predetermined value of W/A. In addition it is possible to predict whether the panel will fail in Euler buckling or yield in material compression.

It is apparent that where a compressive curve of some particular S value strikes the corresponding buckling curve of similar S value, there is a cut-off point. That is, the panel will no longer fail by buckling, but will yield in compression thereafter. Similarly, if the point of intersection of 2 compressive S and t curves lies below the intersection of 2 buckling curves of similar S and t values, the panel will fail in compression before it can develop the maximum buckling load, at some predetermined W/A value. It is apparent from Fig. 16, the Alclad and balsa combination, that sandwiches of cores over approximately $1^1/_4$ in. will fail in compression, whereas those with cores under $1^1/_4$ in. will yield in buckling. From Fig. 17, the Fiberglas and balsa combination, sandwich panels with cores from 0 to approximately 1.6 in. will fail in buckling whereas those with cores over 1.6 in. will fail in compression. The envelope of the buckling cut-off points

on both plates has an increasing slope as measured from the origin, indicating increasing efficiency factors as W/A is increased. Thus the heavier type panel design should prove more satisfactory. A superimposing plot of the cut-off envelopes of Figs. 16 and 17 will indicate that for any value of W/A, the Alclad and balsa combination will develop greater buckling loads than the Fiberglas and balsa combination.

There is an additional type of panel failure possible which has not been analyzed herein due to the complexity of its nature and the resulting mathematics. The phenomenon is one wherein the core material suffers from shear deformation severely when carrying a considerable portion of the end load and buckles into its own wave pattern independent of the face material. In distorting locally, the core is unable to support and stabilize the face continuously and allows the face to buckle locally. This then is a crinkling failure as differentiated from a buckling or compression failure. A treatment of the crinkling phenomenon is contained in a recent article.[5]

An analysis of the flexural properties of the sandwich panels could be conducted readily by using the same parameter EI/b and converting this to load per unit width in terms of the deflection of a cantilever beam or simply supported beam. The cut-off points would then be determined by the ratio of the modulus of rupture to flexural modulus of elasticity for the face and the core.

It is emphasized that no experimental data are as yet available to correlate with the analytical predictions noted herein.

PART IV

It is perhaps well to introduce at this point a discussion of the structural considerations of plastics when contemplated for use in specific detail components of the airplane and point to generalized trends. For example, in the design of cylindrical or elliptical sections for a fuselage consisting of relatively thick skin and very few longitudinal members or stiffeners and numerous bulkheads, it is apparent that the fuselage skin must be relied upon to absorb or carry all of the torsion resulting from unsymmetrical tail loads. Lacking stiffeners the skin would then be required to maintain a high shearing strength and shear modulus. It is quite feasible in a molded type fuselage to utilize a geodetic type of construction for this purpose, wherein layers of the plastic material are cross-banded in sheets at 45° to the longitudinal axis of fuselage. The sheet would have to maintain a reasonable compression and tensile strength under these design conditions. Under this type of orientation of fibers it is assumed that the long column effect would be reduced by the use of several bulkheads.

Selecting an arbitrary wing design, let us assume a wing of single beam construction with a single shear web attachment located toward the aft portion of the chord station; the wing panel could be molded in 2 pieces to be attached to each other along the longitudinal line just aft of the main beam. Assuming that the forward portion of the section, from leading edge to main beam, is a stiff torsion D-box or nose beam, the skin would be relied upon to transmit all lateral shear in a chordwise direction to the main beam. Primary bending loads could be carried by the main beam and very few stiffeners could be employed in the heavy-gage nose section. The introduction of local thickness variations in the nose section might be sufficient to act as stiffeners about regions of cut-outs. The rear shear web could be used to complete the torsional rigidity of the wing cross section and also to carry local hinge moments coming in from the aileron and flaps.

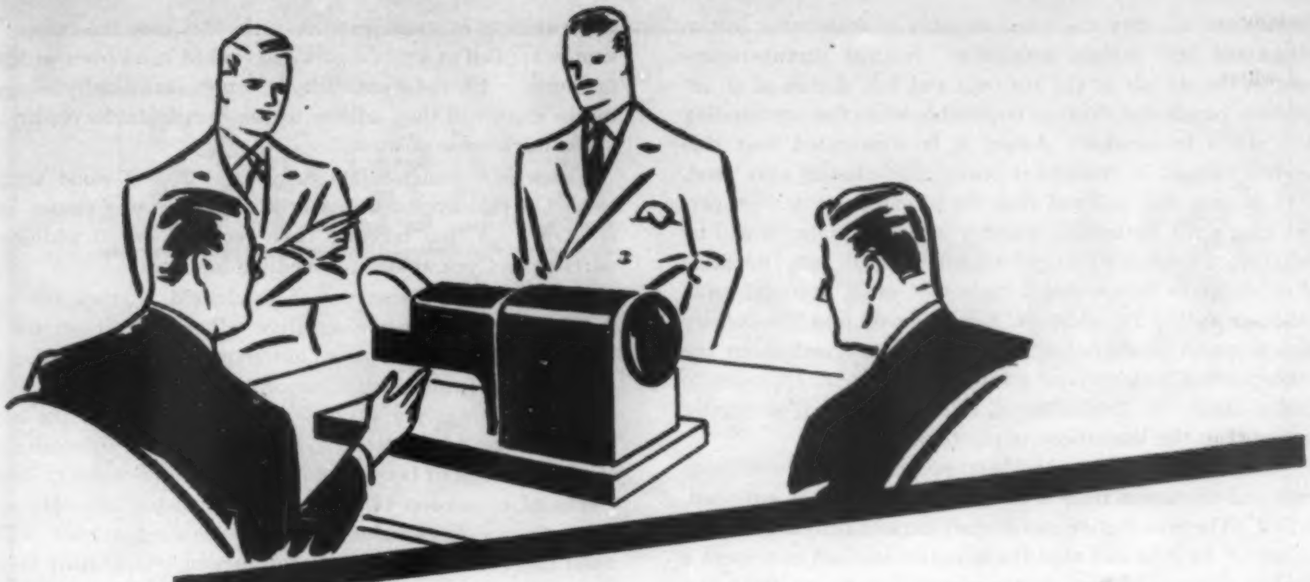
The major difficulty arises in providing a firm and rigid attachment between the 2 panels which presumably must be mechanical. Such an attachment will introduce critical bearing and tensile strains in the plastic sheet and will consist of regions of high stress concentrations. Undoubtedly it would be almost impossible to effect a weight saving at these regions in view of the large mass of material required to reinforce points of stress concentrations. Secondary stresses due to air pressure loading in both flexure and shear will be absorbed satisfactorily by the normally heavy-gage material used for the skin. If the mechanical connection between the panels is satisfactory, the torsional rigidity of the entire cross section will be ample. As noted in the previous analysis conducted on flat and curved plates in end compression, the primary compressive stresses will be well taken care of in the use of heavy-gage material without severe weight penalties if the local end fixities are satisfactory.

At points of high stress concentrations at the root sections where all the bending loads must be transmitted to the center panel or fuselage, it may be necessary to use large mass reinforcements in long laps in order to satisfactorily distribute the loads from the fitting into the beam. At points of low stress concentrations that experience large deflections such as the tip sections of the wing, it appears that sufficient rigidity can be obtained with plastics without sacrifice of weight in view of the fact that the plastics can be oriented so that the fibers are unidirectional with a corresponding large increase of strength in the direction of the fiber. It would appear that such material could be used best on the outboard portions of the wing toward the tip where combined loadings are somewhat minimized.

PART V

To summarize, there are several distinct difficulties that have arisen with metallic structures in the past that have caused, either directly or indirectly, a series of structural failures both primary and secondary. They are: 1. skin wrinkles, 2. lack of internal damping capacity, 3. overall lack of rigidity and 4. intense shear lag. Although surface cleanliness cannot be listed in this group, it is nevertheless a source of difficulty in so far as it tends to decrease speed and maneuverability performance. It is believed that in many ways the plastics have certain structural qualifications that may enable the airplane designer to overcome some of these faults listed above.

Skin wrinkles that introduce drag effects and lead to tension and compression fields forcing part of the skin out of action would be overcome by the necessity to use thicker gage material in plastics for equal weight considerations. Test results have proved the larger amount of internal damping capacity present in plastics over metals, and this should result in better flutter characteristics for the structure particularly in the torsion flexure modes. The overall lack of rigidity in the structure particularly in control surfaces, resulting in stick forces becoming unusually large at certain conditions of flight, could also be overcome in designing the control surface around the monocoque conception. In the case of shear lag where the general ineffectiveness of thin metallic skin tends to overload shear webs and beams and causes large concentrations of load at flange corners, again the heavy-gage plastics in the skin should serve to absorb its normal proportion of the shear load and decrease the flange loadings. General surface cleanliness can only be achieved if cut-outs on wing and fuselage sections are kept to a minimum. Unfortunately this is not always possible if modern combat



aircraft are to carry the usual amount of equipment in the wings and still remain accessible. Normal protuberances exist in the metals at the cut-outs and full closure of all inspection panels and doors is impossible when the surrounding skin starts to wrinkle. Again, it is anticipated that this tendency might be reduced if heavy-gage plastics were used.

In general it is believed that the primary physical properties which will determine whether a plastic material will be suitable for aircraft structural use will be the density, modulus of elasticity in flexure and compression and the compressive yield strength. In addition, it is believed that low-density high-strength plastic structures must be designed about the conception of a monocoque structure, that is, an approach to design about the limitations of ultimate material strengths, rather than the limitations of elastic instability.

The material that has just been presented is open to criticism and discussion from several viewpoints. It is intended, in fact, to be provocative and to start some healthy arguments. However, let it be said that the intention was not to present a final evaluation of any plastic material or to set forth the final methods by which plastics will be designed. Rather, an attempt has been made to show that low-density plastics viewed in the light of the most modern design conceptions, present some possibility of taking their place among useful structural materials, and further, show some promise of making possible improved structural and aerodynamic efficiency of aircraft.

Acknowledgment

The author wishes to acknowledge the aid and assistance of the following personnel of the Naval Aircraft Factory: Lt. (jg) M. E. Soennichsen, A. H. Mann, M. L. Roberts, and especially L. I. Meisel for his contribution to the sandwich analysis.

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[2] L. G. Dunn, "An Investigation of Sheet Stiffener Panels Subjected to Compression Loads with Particular Reference to Torsionally Weak Stiffeners," NACA Technical Note 752 (Feb. 1940).
[3] S. Timoshenko, "Theory of Elastic Stability," McGraw Hill (1936).
[4] The balsa properties are taken from "Sandwich Construction—Preliminary Physical Properties of Balsa Wood," Naval Aircraft Factory Report TED No. NAF 2408, Part 1 (June 30, 1943).
[5] G. S. Gough, C. F. Elamn and N. A. DeBruyne, "The Stabilisation of a Thin Sheet by a Continuous Supporting Medium," Journal Royal Aero. Society (Jan. 1940).

Cycleweld

(*Continued from page 69*) plastic pieces Cyclewelded to metal fittings have been produced for aircraft use.

Plastics to plastics—This application has not as yet found a large place in war production, due to the inflexibility of current designs and specifications, but it has a large future. Any plastics that can withstand the curing temperature can be successfully Cyclewelded together. Laminated phenolic plastics by the Cycleweld method are stronger than conventional laminates. Even some thermoplastics may be Cyclewelded at temperatures up to 250° F.

Plastics to wood—This union has been successfully accomplished with radio frequency heating methods.

Rubber to ceramics—A typical application is the permanent affixing of a rubber knob directly to a glass window by Cyclewelding.

In addition to the forms of Cycleweld cement described above, the company is now bringing out Cycletape, a tape form which is expected to be useful in making field repairs of damaged aircraft. This is simply the first type of cement roll-coated on cellophane for easy application.

There is in addition a recent development known as Cyclebonding, which in effect eliminates the necessity for Cyclewelding in some instances. In this case the cement is simply applied to a metal part and cooked in an oven without pressure. Phenol-formaldehyde, urea-formaldehyde and casein glues will then adhere to this cured film as readily as in the lamination of wood.

Altogether, some 30,000 metal and 20,000 wood Cyclewelded parts have been produced for use in war planes, and an Army o.k. has recently been received on 55 additional parts to be Cyclewelded for medium bombers.

Saunders, the discoverer of Cycleweld, started research 5 years ago on pressure-sensitive adhesives. Interested in the application of plastics to automotive body structures, he saw plastics' future in lamination with metal, wood or some other strength-giving substance, and he saw that the combination would have to have a layer or rubber or some such elastic material in between to absorb the difference in coefficients of expansion of two dissimilar materials. He first tried thermoplastic glues on prevulcanized rubber. This bond had high strength, but the range of temperature resistance was narrow.

Finally, working with other Chrysler engineers, Saunders developed a thermosetting plastic glue. He discovered that a round "tension button" of rubber could be bonded so firmly to sheets of phenolic laminates that the rubber would tear before the bond gave way (Fig. 16). The thermosetting glue gave better results at low temperature, and experiments were continued in this direction. It became possible to bond directly together a wide variety of materials, the cement distributing the load over the whole Cyclewelded surface in virtually unbreakable union, while at the same time providing a "cushion" to absorb the necessary differences of expansion.

Saunders believes that Cycleweld processes will find a postwar use in practically every type of structure where it is desirable to get the utmost strength out of each pound of material. The ideal structure, Saunders says, has not yet been built. It will be, he thinks, two sheets joined by some such process as Cyclewelding—one sheet for lightness of weight and one for strength as, for instance, wood veneered to metal, or plastics to wood or metal. Cyclewelding will allow fabrication from sheets of plastic by lapping or joining, thus apparently making practical the previously visionary designs of plastic-surfaced, contoured automobile bodies.

Where plastic is joined to metal, says Saunders, Cyclewelding will be essential to provide a firm bond which will still allow the differing materials to move in their own coefficients of expansion. He believes there is a tremendous future for Cyclewelding in furniture, providing the strength of metal construction with a wood veneer surface. There is the possibility that a similar metal and wood veneer laminate may prove to be the most practical automobile body. It would provide the same strength as the present metal body at much less weight, and could be made to provide certain qualities of sound-deadening and insulation.

Possibilities of Cyclewelded construction in housing are already being explored. A Detroit concern in large-scale production of prefabricated housing has placed an order for floor panels formed of corrugated .010-gage steel between two sheets of $^1/_4$-in. plywood which will have $^1/_3$ the bulk of present panels and far greater strength than is needed. If lighter-gage steel were produced, it would be adequate. Such housing panels can be produced in any size, not only for floors but for side and roof panels. Quickly and cheaply produced, they would provide excellent insulating and noise-deadening qualities through the sealed dead-air space in the inner corrugation.

High-frequency gluing

(*Continued from page 93*) or, most commonly, nails used to hold the various pieces together while in the press. If the nail or metal lies in a plane parallel to the electrodes, there will be no danger of burning. However, if the metal lies in a plane perpendicular to the electrodes, the voltage drop along the metal parts will cause them to heat and ignite the wood. In this case, the applied voltage should be kept at a minimum and the overall distance between electrodes made a maximum. This will reduce the voltage gradient along the metal. Although the metal may get hot, it might be kept below the charring point. A practical solution of each individual problem is necessary since all conditions tend to vary. Where possible, non-metallic nails or fittings should be used. Plastic, hard wood or fiber nails are extremely effective in holding the parts in place. However, the strength requirements naturally govern the use of material for the fittings.

Rib jigs lend themselves to high frequency heating with a minimum of rework. The jigs can be stacked vertically and 3 electrodes used to treat 2, 4, 6, 8 or even 10 at one setting. Figure 6 shows one set-up whereby 4 jigs are heated simultaneously.

As stated previously, metal lying in a plane parallel to the electrodes will not be detrimental. However, any screws used to fasten locating blocks will run perpendicular to the electrodes. If these screws cannot be eliminated, by substituting wood or plastic dowels, etc., the electrode should be shaped to follow the glue surface which usually is far enough away from the screws to prevent any arc-over or hot spots. Metal clips occasionally used in conjunction with rib jigs made from a metal base should be definitely avoided. They are directly in contact with the cap strips and in the field set up by the electrodes. As a result of lying in a plane perpendicular to the electrodes, a potential gradient exists along their length. This voltage is high enough to induce considerable current flow and a consequent sharp rise in temperature. The hot spot thus formed is high enough to cause the cap strip to char or ignite. Leadpencil marks should be avoided as they act the same as metal.

Where it is not possible to get the work between electrodes, as is usually the case in built-up structural assemblies such as wings, ailerons, elevators, stabilizers, floors and the like, the curved field characteristics of the electrodes—i.e., stray field heating—can be utilized.

In the manufacture of wooden aircraft parts, it has been found that wooden jigs and fixtures often are as accurate as similar ones in metal and usually much less expensive. It is extremely desirable and often essential for wooden parts to be assembled and glued under pressures above 50 p.s.i. In such cases, nails will not give the desired results. The parts, therefore, must be kept in the jig while mechanical or pneumatic pressure of some sort is applied. If heat is not applied to the glue joints, the jig is tied up for at least 4 hours. These jigs are usually large and complex. A system has been devised whereby the electrodes in the form of metallic tubing or rods are shaped to follow the joint to be treated. The pressure blocks are recessed so that the electrodes lie flush with the pressure surface. A complete grid work can be designed so that all joints are treated simultaneously.

Many parts of the CG-4A Glider including 3-man seats (Fig. 7) for air-borne troops, ramps (Fig. 9) for the jeeps, sanitary containers (Fig. 10), and empennage members such as the elevator (Fig. 11), rudder, fin and stabilizer, are built in precision jigs that are now wired for high frequency. These jigs locate the parts accurately, apply the necessary pressure to the glue joints, using air pressure hose or springs and introduce heat through the use of the high frequency unit and electrodes built into the jigs. These parts are in the jigs for a period varying from 2 to 15 min. depending upon the efficiency of the electrode design. Sometimes it is physically impossible to locate the electrodes so as to introduce maximum power.

Using this method, it is necessary to have only from 10 to 25 percent of the number of jigs required to produce the parts if no heat were introduced into the glue joints. Since jigs are all assembly units, their cost runs quite high, one or two jigs defraying the cost of a 1-kw. unit usually big enough for stray field heating. With the fewer jigs, the reduction in the necessary floor space allows for decreased overhead costs.

In the case of the elevator assembly, 3-man seat, sanitary container and ramp, the electrodes are $^3/_{16}$-in. diameter brass rods located so as to introduce heat to all glue joints simultaneously. The ramp, 3-man seat and sanitary container are done in 15, 5 and $2^1/_2$ min., respectively. The elevator jig requires about 10 minutes. During this time some parts attain a temperature of 260° F. while the coolest is at 170° F. This difference in temperature is unavoidable since the glue joints are extremely dissimilar and do not allow for an efficient electrode design. Whenever production demands are decreased, the jigs can be allowed to run cold for a 4-hr. period.

The question of the capacity of the machine required is determined by the size, type variety and spacing of work. The leads of these machines should not run over 10 ft. in length. If different presses are to be handled by the same machine, they should be set up so that a minimum of handling will be necessary to reach the electrodes. The weight of the wood placed between electrodes is the prime factor in determining the size of a machine required. If a phenolic resin glue is to be used, the time under pressure should be about 20 min. at 240°, 10 min. at 260° or 5 min. at 280°. At that rate, bringing the temperature up to 280° F. in a period of 15 min. and then permitting it to cool naturally for 15 min. allow sufficient heat to insure complete polymerization of the glue. Since 1 kw. will produce 3413 Btu/hr. using 50 percent of the input as available power:

$$\text{Output} = \frac{3413 \times .50}{60} = 28.4 \text{ Btu/min./kw.}$$

Using 15 min. as our operating time,

$$\text{the Btu available} = 28.4 \times 15 = 426 \text{ Btu}$$

the Btu required to raise 1 lb. of wood from 70° to 280° using .45 as coefficient of specific heat:

$$\text{we have } 1 \times (280 - 70) \times .45 = 94.5 \text{ Btu}$$

since 426 Btu are available, a 1-kw. machine could handle

$$\frac{426}{94.5} = 4.5 \text{ lb.}$$

Therefore a 1-kw. machine is able to raise 4.5 lb. of wood 210° F. in a period of 15 minutes. If a urea-formaldehyde glue with its lower polymerization temperature is used as a bond, the amount of wood treated in 15 min. can be raised to 9 pounds. So long as the electrical capacitance of the work is within the range of the machine, the dimensions of the assembly have no effect upon the heat generated except that full voltage cannot be applied without arcing across the electrodes if the electrodes are too close together. If the presses are widely spaced or on different floors, a machine of 5 kw., or


Saran Screen

smaller, can be used without much difficulty. The operator will experience no trouble in moving the machine.

Although all machines are equipped with built-in safety features to protect the tubes and the operator, additional precautions are advised. Manufacturers of these machines go into detail on these safety features upon delivery. A few simple measures will do much to insure the safety of either

PHOTO, COURTESY STEINWAY & SONS

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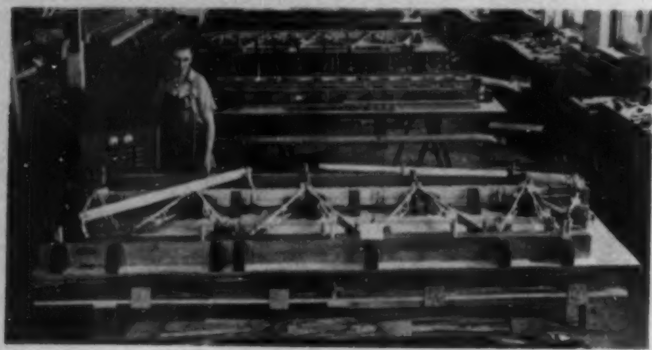


14—*Here a complete elevator is in position in jig, with transmission lines for high-frequency power running completely around the form. Unit glues 27 joints in 7 min.*

those passing by or those operating the machine. By far the most effective indication that there is high frequency power being transmitted is the illumination of a worn industrial fluorescent bulb when brought in close proximity to the electrodes. By locating these bulbs about the press and painting suitable warnings on their surfaces, painful accidental burns may be prevented. Telescopic gates (Fig. 12) located about the press have switches set up so that the opening of the gate opens the plate circuit of the output tube and automatically shuts off the power. Built-in timing devices to shut off the power at a predetermined time and other refinements also are in use with these machines.

Present molding methods now are undergoing radical changes. Since the electrodes can appear as wire, rod, sheet (both flat and formed) and sprayed metal, there is no shape that cannot be heated successfully with high frequency voltages. A small portable electrode in the form of a gun is now in use at Steinway & Sons in "nailing" skins and "ironing" glue joints. This "gun" is connected by a long lead to a medium sized transmitting unit operating at approximately 100,000,000 cycles per sec. and applied with a trigger that is actuated when power is desired. The gun case is grounded and therefore presents no electrical hazard. Figure 13 shows an application of this unit, a cleat being added to a fuselage nose skin that is being spliced. The amount of heat required to set the glue is obtained in a few seconds.

It is obvious that one important phase of the difficulties that faced the woodworker when he was told to prepare for mass production have been removed to a large extent. Final assembly, the bottleneck of most industries, has thus been brought under control in the woodwork industry at a minimum cost with improved quality. Other applications of this form of high-frequency heating to thermoplastic and thermosetting plastics have also been made. Since these applications are relatively simple and fall under the heading of perpendicular heating, all calculations that apply to wood can be applied to synthetic plastic that are preheated before forming. Paint finishes that have not responded to oven and infrared drying have been found to set rapidly and properly, using grids that have been designed to heat the surface with stray electrostatic fields. In all, the use of this type of heating still is in its infancy. In time to come it is bound to bring about unthought of uses, for once the speed, comparative simplicity of application, ease of operation and—particularly—efficient electrode design are better understood, this will be inevitable.

Jettison tanks

(*Continued from page 77*) a structural test far more rigid than actual flight conditions necessitate. Tanks were loaded with 15,000 lb. of lead and left suspended by slings (Fig. 7). Both material and structure withstood the test.

Every tank is given a leak test before shipment. Fuel is pumped into the jettison tanks and a pressure of 4 p.s.i. is applied (Fig. 9). The tanks then are turned and tilted in every direction to check leakage. Before installation in bombers the tanks undergo further tests at the plants of the Glenn L. Martin Co. Pressure and drop tests are made as a further guarantee that the tanks will stand up under the most rigorous flying conditions. However, it is not intended that the tanks be reused after they are jettisoned.

The jettison tank will undoubtedly find increasing use as we swing to the offensive. It will be particularly valuable in ferrying planes to bases in the Pacific theatre where airline distances are so vast. Even the island to island approach to Japan involves air jumps of thousands of miles. Jettison tanks may be counted upon to help our fighters cross the miles to victory.

Credits—Material: Valinite. Resin: Plaskon. Molded by Virginia-Lincoln Corp. for Glenn L. Martin Co.

Steel shell case coating

(*Continued from page 74*) Here a current of 130,000 volts sets up a powerful electric field and pulls the bead of varnish off in a fine spray (Fig. 4).

Inspection of the shell cases for final acceptance by Army Ordnance includes exacting tests of the corrosion and abrasion resistance provided by the resin coating (Fig. 5). One unusual type of inspection tool has been developed to permit close observation of the interior wall of the case. A cone-

5—*Final inspection includes gaging and checking of the coated surfaces for corrosion and abrasion resistance*

PHOTO, COURTESY BUICK MOTOR DIV., GENERAL MOTORS CORP.

5


shaped piece of steel slightly smaller in diameter than the case is chromium plated to a mirror finish on its outer surface. A wire is attached to the apex of the cone, and a small light arranged to illuminate the interior of the case and the bright surface of the cone. The unit is lowered to the base of a case and drawn slowly upward while the inspector watches the mirror surface. The inside of the shell case is reflected in magnified form so that any interior surface defects are readily observed.

This resin coating of steel shell cases is a recent development. When the cases first went into production, corrosion and spark resistance was supplied by the use of copper-clad steel for the blank, or by plating the shell with a thin film of copper. The resin coating, however, proved equally efficient and made possible the conservation of a large amount of copper.

Credits—Material: phenolic resin. Sprayed coating by Buick Motor Div. of General Motors Corp.; dipped coating by Electric Auto-Lite Co.

Washington round-up

(*Continued from page 130*) control of GMPR and establishes dollars-and-cents ceilings based on March 1942 prices at individual plants as the maximum producers may charge in their sales of coal tar.

RENEGOTIATED WAR CONTRACTS

Renegotiations of war contracts by the price adjustment agencies of the War and Navy Departments and the Maritime Commission through June 30, 1943, resulted in commitments for the elimination of excessive profits in the amount of $3,555,174,000, according to a joint report issued in August. Of the total for the 14 months since the authorization of the three Price Adjustment Boards and their associated agencies, $1,523,748,000 represents the recovery of excessive profits realized and $2,031,426,000 represents price reductions for future deliveries on existing contracts.

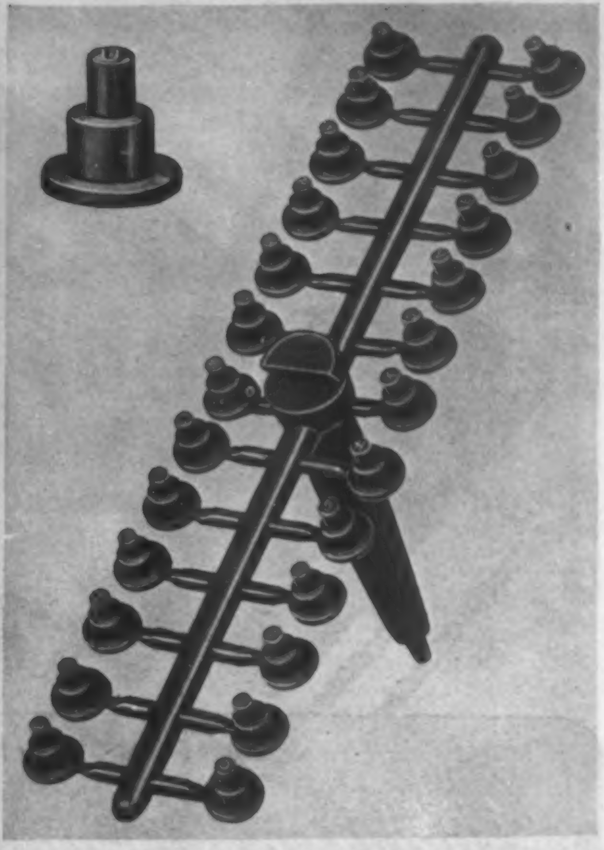
The rate of renegotiation is continuing to be substantially accelerated, the agencies report. A of the end of June, written or oral agreements covering 1942 fiscal year prices and profits had been reached with 3611 war contractors.

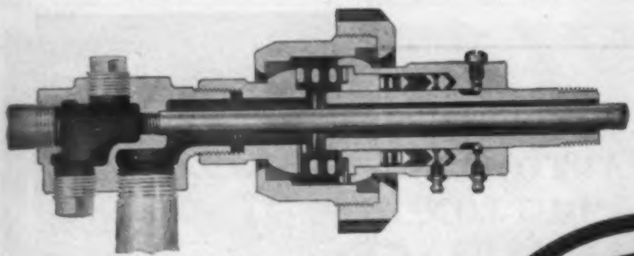
ARMY AND NAVY COOPERATE IN AUDITING

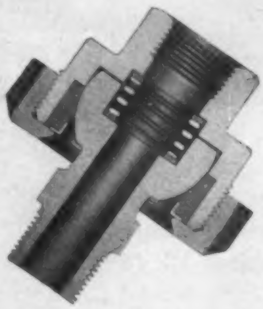
The War and Navy Departments have inaugurated a program to eliminate overlapping audit functions wherever possible, the agency having the predominant interest in any contractor's work functioning for both. Thus the war contractor will be saved the delay and trouble caused by dealing with two separate audit staffs, and the Government will be saved the expense of avoidable duplication. Already the close cooperation existing between the Services and the fact that there is no substantial difference in their cost concept have made it possible to consolidate the auditing activities of the Army and Navy in the plants of several contractors engaged in work under cost-plus-a-fixed-fee contracts. Extension of this program is in progress.

NEOPRENE PRICE FIXING

Effective Aug. 14, 1943, amendment 3 to MPR 403 provides that the prices for synthetic and substitute rubber in effect on Aug. 1, 1943, must be used in determining the ceilings of commodities containing those materials which are covered by the regulation. Only sales of articles for the use of the Government are involved. OPA states that the reason for decreasing the price of neoprene from 45 cents to $27^1/_2$ cents is so that it will be reflected in the maximum prices paid by the Government for a variety of products in which synthetic rubber is used.







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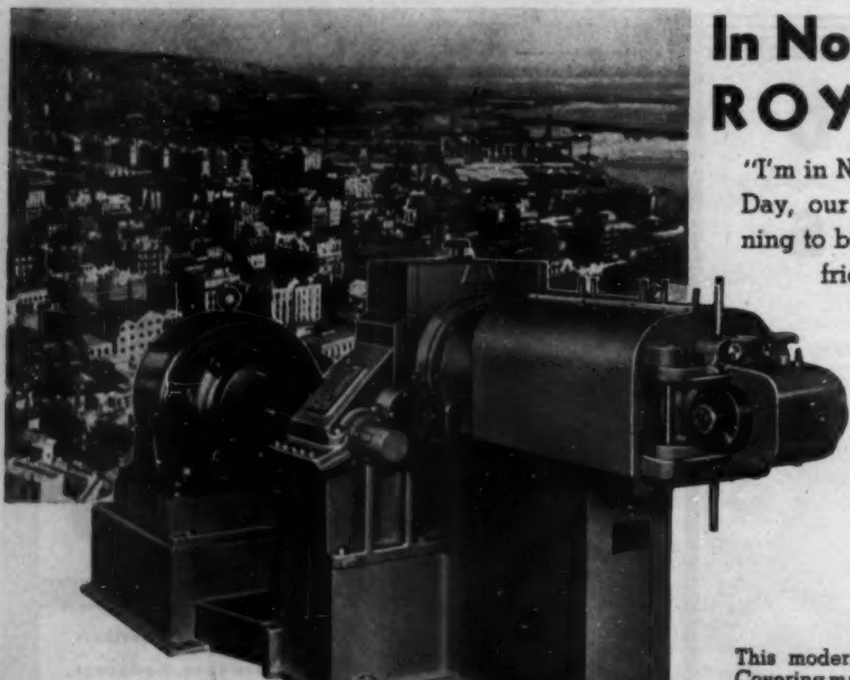

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D B NEWS

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D-B Develops Plastic Razor With Telescopic Handle

IRVINGTON, N. J.—The successful development of a new molded safety razor in which the two-section handle telescopes together has recently been announced by the Dillon-Beck Mfg. Co. When in use, the handle is firmly held in its extended position by means of an ingenious taper design of the two parts.

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Designed for military use, the razor is practically the same size, when extended, as the present army model. Telescoped in its box, however, it is less than one-half the size. In addition to being lighter and more compact, this feature saves 192,000 lbs. of material in each million boxed units.

After the war, company plans call for promotion of the razor as an item applicable to widespread civilian use.

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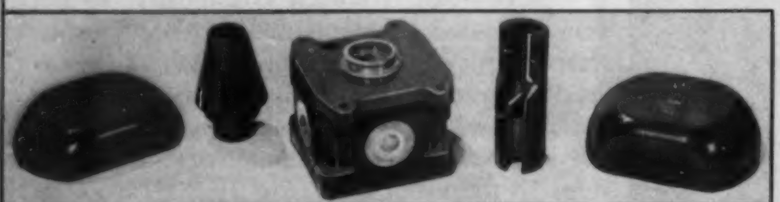

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WANTED

RESEARCH CHEMIST

WITH KNOWLEDGE OF PLASTICS, PHENOLIC RESINS, SYNTHETIC RUBBERS, ETC. COMPOUNDING AND MOLDING. FLEXIBLE AND HEAT RESISTING PRODUCTS FOR MECHANICAL INSTALLATIONS, INTERNAL COMBUSTION ENGINES AND ALLIED ACCESSORIES. APPLICANT MUST HAVE DEGREE IN CHEMISTRY AND BE BETWEEN THE AGES OF 30 AND 45. STATE EXPERIENCE FULLY. EXCELLENT SALARY COMMENSURATE WITH ABILITY. DEPENDABLE POST-WAR PERMANENCY WITH REPUTABLE INTERNATIONALLY KNOWN ORGANIZATION. COMMUNICATIONS WILL BE HELD STRICTLY CONFIDENTIAL. ADDRESS: MODERN PLASTICS, Box 841

WANTED

Will purchase outright small or medium size injection molding plant with or without tool room. Replies from any location will be welcome and will be held in strictest confidence. Reply Box 842, Modern Plastics.

I AM ANXIOUS to contact manufacturers of all types of plastic articles and plastic bonded laminates for industrial and domestic use for exclusive distribution rights in large potential post-war markets in the rapidly growing Northwestern states. Reply Box 843, Modern Plastics.

VINYLITE SCRAP

Wanted by a client Manufacturer for own use.

Will purchase your scrap regularly.

In any quantity and pay

highest prices.

NATIONAL BROKERAGE CORPORATION

110 William Street, N. Y., N. Y.

Cortland—7-0910

MOLDS AND DIES WANTED

Attractive prices will be paid for new or used molds and dies for the manufacture of the following articles:

side combs
tuck combs
pocket combs
men's combs
dressing combs
bobby combs, etc.

These molds and dies to be used on injection molding machines, preferable Reed- Prentice.

Address Box 844, Modern Plastics

POSITION WANTED: Plastic Engineer thoroughly experienced in fabricating and production of plastic materials. Knowledge of machinery and dies for compression and injection molding. Ability to set up and operate plant. War work preferred. Draft exempt. Reference available. Reply Box 845, Modern Plastics.

PROGRESSIVE SALES ORGANIZATION covering all industries of the St. Louis trade area desires additional accounts in Plastics lines. We wish additional sources of compression, injection, jet mouldings, extrusions, and laminated products with aggressive houses. We have post-war prospects now on file. Excellent warehouse facilities available. May we correspond with you regarding future business relationships? Reply Box 846, Modern Plastics.

CHEMIST—FOR NEW FIELD

Chemist to take charge of wood plastic molding department and set up experimental laboratory. Plastic chemistry experience desirable. Write age, background, draft status.

Briarwood Corp., 2810 Superior Avenue, Cleveland, Ohio

ASSISTANT MOLDING SUPERINTENDENT WANTED

Compression molder in Middle West doing 100% High Priority War Work requires experienced assistant molding superintendent. Reply to Box 847, Modern Plastics, stating age, present employer and present salary, availability for new position, and draft status.

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60 second finish!

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COATINGS that air-dry in one minute or less, yet provide maximum durability and resistance to moisture, are helping to speed the production of our fighters and bombers—giving extra protection to light metal aircraft components, and permitting quick "touch-up" of aircraft repairs in the field.

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